GURPS®

BIO-TECH™

THE NEXT STEP IN HUMAN EVOLUTION

BY DAVID PULVER

STEVE JACKSON GAMES

GURPS®

BIO-TECH™

The Next Step in Human Evolution

By David Pulver

Additional Material and Research Assistance by
Stan Berry, Steve Dickie, Benjamin Diedrich, Karl Diedrich, Peter Donald, Scott Farrow, Laurel Halbany, Elizabeth McCoy, John Nowak, Peggy Pulver, Timothy Pulver, and Sean Punch

Edited by Sean Punch
Illustrated by Dan Smith

GURPS System Design by Steve Jackson
Gene Seabolt, Chief Operations Officer
Sean Punch, ***GURPS*** Line Editor
Page Layout and Typography by Olen Everett Cone
Cover and Interior Production by Carol M. Burrell
Print Buying by Monica Stephens
Art Direction by Carol M. Burrell

Playtesters: Ed Bradley, Ray Cochener, James R. Dunson, Scott Farrow, John L. Freiler, Mark Halsall, Paul D. Henrichsen, Bob Huss, Scott A. Hutchens, Daniel Jasman, Jr., Hunter Johnson, Don Juneau, Jonathan Lang, M. A. Lloyd, Elizabeth McCoy, Phil Masters, Aaron Medwin, Chris Murray, John Nowak, Nana Yaw Ofori, Ian Osmond, Chris Owen, Timothy Pulver, Gary W. Roe, Curtis Shenton and Bolie Williams IV

ISBN 1-55634-336-1

2 3 4 5 6 7 8 9 10

STEVE JACKSON GAMES

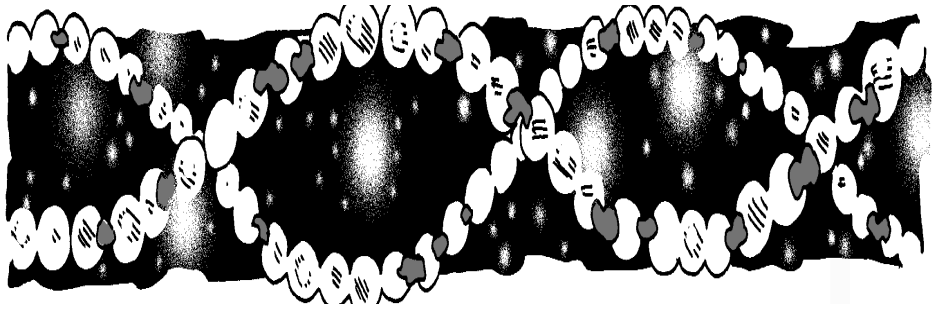
CONTENTS

INTRODUCTION

Genetic engineering and other biotechnology are about to change the world in ways we can only begin to guess at.

Can we resist the temptation to tinker with our genes when the potential rewards include immortality? Will exotic wonder drugs soon be produced in cows and goats? Will genetically-enhanced plagues threaten to wipe us out, or will bio-nanotech let us conquer disease and transform ourselves into post-human superbeings? Just how do genetic engineering, cloning and braintaping work, anyhow?

GURPS Bio-Tech answers these and other questions by looking at current and future technologies from a science-fiction perspective. In this book, we'll take a detailed look at many of the biotechnologies that other ***GURPS*** books have taken for granted and see how they stack up against the latest developments in the real world. The answers may surprise you . . .



Using This Book

Biotechnology breeds its own jargon. While most unfamiliar technical terms are explained as they are introduced, definitions can also be found in the *Glossary,* p. 139. If you run into an obscure term, check the glossary.

This book introduces few new advantages or disadvantages, but does add a wide range of new enhancements and limitations. These are explained in the *Appendix,* p. 135.

Finally, fictional quotes introduce many sections of this book. Capsule biographies of our "commentators" appears in Chapter 6, in the sidebars on pp. 132-34.

About the Author

David L. Pulver is a freelance writer and game designer based in Kingston, Ontario. He is the author or co-author of over 20 books, including a novel and various roleplaying supplements, such as ***GURPS Reign of Steel*** and ***Psionics,*** and ***Bubblegum Crisis: Before and After*** (for R. Talsorian Games). David's interests include science fic-

About GURPS

Steve Jackson Games is committed to full support of the ***GURPS*** system. Our address is SJ Games, Box 18957, Austin, TX 78760. Please include a self-addressed, stamped envelope (SASE) any time you write us! Resources now available include:

Pyramid (**www.sjgames.com/pyramid**). Our online magazine includes new rules and articles for ***GURPS***. It also covers all the hobby's top games – ***AD&D, Traveller, World of Darkness, Call of Cthulhu, Shadowrun*** and many more – and other SJ Games releases like ***In Nomine, INWO, Car Wars, Toon, Ogre Miniatures*** and more. And *Pyramid* subscribers also have access to playtest files online, to see (and comment on) new books before they're released.

New supplements and adventures. ***GURPS*** continues to grow, and we'll be happy to let you know what's new. A current catalog is available for an SASE. Or check out our Web site (below).

Errata. Everyone makes mistakes, including us – but we do our best to fix our errors. Up-to-date errata sheets for all ***GURPS*** releases, including this book, are always available from SJ Games; be sure to include an SASE with your request. Or download them from the Web – see below.

Q&A. We do our best to answer any game question accompanied by an SASE.

Gamer input. We value your comments. We will consider them, not only for new products, but also when we update this book on later printings!

Internet. Visit us on the World Wide Web at **www.sjgames.com** for an online catalog, errata and updates, and hundreds of pages of information. We also have conferences on Compuserve and America Online. ***GURPS*** has its own Usenet group, too: rec.games.frp.gurps.

GURPSnet. Much of the online discussion of ***GURPS*** happens on this e-mail list. To join, send mail to majordomo@io.com with "subscribe GURPSnet-L" in the body, or point your World Wide Web browser to: **www.io.com/GURPSnet/www**.

Page References

See ***GURPS Compendium I,*** p. 181, for a full list of abbreviations for ***GURPS*** titles. Any page reference that begins with a B refers to ***GURPS Basic Set, Third Edition Revised;*** e.g., p. B144 refers to page 144 of ***Basic Set.***

CI refers to ***GURPS Compendium I,*** CII refers to ***Compendium II,*** CW to ***Cyberworld,*** CY to ***Cyberpunk,*** FF to ***Fantasy Folk, Second Edition,*** P refers to ***Psionics,*** RO to ***Robots,*** S to ***Space, Second Edition,*** SU to ***Supers,*** Second Edition, UT to ***Ultra-Tech, Second Edition Revised,*** UTT to ***Ultra-Tech 2*** and VE to ***Vehicles, Second Edition.***

1 BIOTECHNOLOGY

Tika Dawnstar frowned – she needed money. Her scholarship covered her tuition in the University of Mars' genetic engineering program, but cost of living at Nix Olympica was awful, thanks to the terraforming taxes. She needed a winter job, one that would pay for the cutting-edge neurovirus with which she hoped to upgrade her brain in time to ace the upcoming term's exam.

Plugging into her biocomputer, she scanned the "Help Wanted" column on GeneWeb. Assistant on a project to develop a pollution-eating, cryogenic bacteria to clean up a vatspill on Titan? Bleah. Design new porkapple plants? Yuck. She was a vegetarian, anyway. She scrolled down the page, then stopped. High Arcadia was an orbital habitat – an adventure theme park based on Greek mythology. They wanted a freelancer with grad-level expertise to design one of the creatures that would populate the park: a lamia, with a snake's body and a human head. Tika's eyes widened . . . The lamia was to be fully sapient!

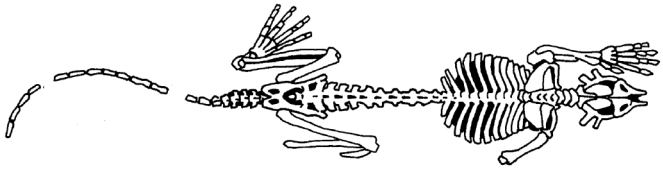
Wasn't that illegal? Tika called up a law database and cross-checked: Nope. It was bioethically questionable, but High Arcadia was an autonomous extra-national entity, not a signatory to the Genetic Regulatory Protocols; she could work with human DNA. Tika hugged herself – this would be fun!

She considered the problem. A snake/human cell fusion, so she'd have to smooth out the biochemical differences between species . . . and probably get lots of false starts and aborted embryos before she got it right, even if she rented time on the university's vatbrain megacomputer. But she could do it with the facilities they were promising, and the advance would pay for her new brain! Humming to herself, Tika began composing her application letter to the Arcadia Entertainment Group.

Biological manipulation is nothing new. Humans have been influencing the genetics of plants and animals for thousands of years through selective breeding. For example, most sheep once had long legs. That's better for the sheep, since they can run away from predators, but not so good for a farmer, who finds it harder to control and shear a nimble animal. So shepherds bred the sheep with shorter legs together. The result? After many generations, the "improved" sheep are all short-legged, and farmers need specially-bred sheep dogs to keep the predators away.

The trouble with selective breeding is that it takes generations to produce results. Consequently, much of what we know about genetics comes from studying organisms that have relatively short lifespans, such as fast-growing plants, fruit flies or bacteria.

Today, dramatic breakthroughs in molecular biology have led to genetic engineering, a technology that allows the work of centuries to be done in months or years. In the 21st century, gengineering may create modified animal species, or even an "improved" breed of human. But who determines what is an "improvement" – the sheep or the shepherd?



Basic Principles

All terrestrial life is made up of *cells:* one cell in the case of simple organisms like bacteria or protozoa, and about 800 billion in a human. A cell consists of a membrane which encapsulates a watery soup of subcellular bodies. Among the most important of these are skinny strands called *chromosomes.* Bacteria (the simplest life forms) have a single chromosome (and several, smaller ring-shaped bodies called *plasmids*). In more complex forms of life, multiple chromosomes are housed inside a nucleus in the center of the cell; e.g., each human cell contains 23 pairs of chromosomes. Every cell in a particular organism, except the reproductive cells, has the same number and type of chromosomes. Collectively, the chromosomes form an instruction manual that contains all the information an organism needs to grow and reproduce.

Biotech Tech Levels

TL1-3 (pre-1450). Farming leads to a practical understanding of basic heredity; plants and animals bred for desired traits. Microbes exploited to make bread, wine and cheese.

TL4 (1450-1700). Development of the optical microscope makes cells visible for the first time.

TL5 (1701-1900). Mendel develops laws of heredity. Nature of cells and reproduction understood. Germ theory of disease developed, along with early vaccines. Darwin postulates evolution. Galton theorizes eugenics.

TL6 (1901-1950). Mutation of plants and microorganisms using chemicals and radiation. Biochemistry comes into its own. Penicillin and other antibiotics developed. Electron microscope allows viruses to be seen. Experiments in eugenics.

TL7 (1951-2000). DNA, chromosomes and genes discovered, related to heredity. Genome mapping begins. Recombinant DNA and transgenics allow simple gengineering. Organ transplants, genetic testing, and experimental gene therapy and cloning.

TL8. Human genome is mapped and sequenced, along with the genomes of many other terrestrial animals. Complex genetic modifications become possible. Cloning perfected. Artificial wombs ("growth tanks").

TL9. Mature gengineering. Limited genetic control over mental traits. Development of bio-nanotechnology permits braintaping and the use of nanoviruses in germline gengineering.

TL10. Gengineering of complex mental traits, such as intelligence. Routine genetic reconstruction of ancient DNA traces.

TL11. Living machines. Sensa-skin. Nanoviruses and gengineering can alter the fine structure of an adult mind.

TL12. Complex nanoviruses, including contagious ones, make radical transformations possible in humans and animals.

TL13+. Near-total control over biological processes through mature nanotechnology. Chrysalis machine.

The time frame after TL7 is simply speculation. Also, while the ***GURPS Basic Set*** suggests that TL8 may represent 2001-2050, it's possible that biotechnology will outpace this – in fact, if the wildest prophets of molecular nanotechnology prove to be on target, we might even see a TL increase in the field of biotechnology each generation, or even each decade! Thus, instead of being "far, far future," TL13 biotech may be 2100 or even 2050!

Continued on next page . . .

Biotech Tech Levels (Continued)

This assumption has been incorporated into some of the vignettes in later chapters, which explains why several of the personalities "live through" multiple tech levels.

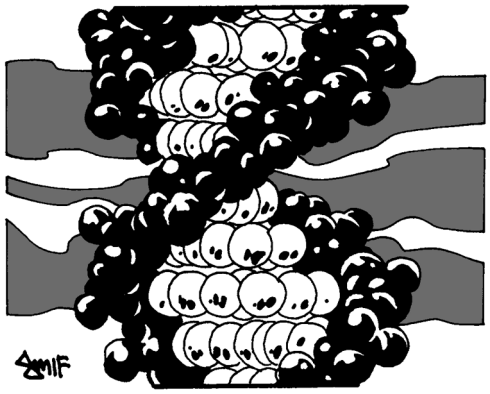
Tech Level Variations

It's perfectly possible to have a society in which certain developments in technology, such as biotech, are more or less advanced than other types of technology. In fact, this is strongly recommended for certain campaign settings.

For instance, the average cyberpunk world background (as described in ***GURPS Cyberpunk***) may be TL8 overall, but medicine, biotech and cybernetics are usually at TL10 or TL11 – sometimes even higher. A "nanopunk" world may be TL8-9 in the physical sciences but TL12-13 in biotech and nanotech.

Likewise, some alien species or exotic human cultures may follow a different path, leading to TL9+ in biotech but a much lower tech level in other areas. This is especially likely for aquatic species, or those evolving in gas giant atmospheres.

GMs should also feel free to adjust the tech level at which different biotech inventions appear. If you think braintaping should be TL12 rather than TL9, there's no real reason why it can't be . . .



Chromosomes are made of deoxyribonucleic acid, or *DNA.* This is a long, complex molecule with a tightly-coiled "double helix" shape, resembling a twisted ladder. The "rails" are formed from deoxyribose sugar and phosphate molecules, while each "rung" on the ladder is composed of two compounds, called *bases,* locked together to form a pair – either the molecules adenine and guanine (an AG pair), or cytosine and thymine (a CT pair).

If chromosomes are an instruction manual, then these base pairs (approximately 3 billion in a human!) can be thought of as the "letters" in the "genetic code" that it is written in. To continue the analogy, particular arrangements AG or CT base pairs form words, and a single coherent sentence is a *gene.* Each gene (there are as many as 100,000 in a human) contains a specific instruction that tells the cell how to manufacture the chemicals needed for life.

A gene sends out instructions to the cell by making a copy of the genetic code using *messenger RNA* (*r*ibo*n*ucleic *a*cid). Messenger RNA carries a gene's instructions to big, lumpy molecules that float around the chromosome, known as *ribosomes,* which are the cell's biological factories. They read the genetic message written in the RNA as an instruction to start or stop manufacturing a particular protein (see below) from available chemicals.

Proteins are complex molecules (made of amino acids) used in cellular chemical reactions. Some proteins make up the structure of cells. Others, called *enzymes,* act as catalysts to induce molecules to form new combinations, or break complex molecules (such as food) down into smaller components. What differentiates one species or individual from another are the different proteins that their cells produce, and the order in which they produce them. These *metabolic processes* – digesting chemicals from food and making more DNA, RNA and enzymes so that cells can replicate – are what characterizes life on the cellular level.

Cells replicate by splitting in two. When this happens, each of the chromosomes within them also divides down the middle, so that both new cells have a copy of each chromosome. These half-chromosomes then reconstitute themselves from the loose chemicals in the cell. In this way, each cell remains an exact duplicate of the original. In the case of asexual, single-celled organisms like bacteria, this ensures that each one is identical.

Multicellular creatures that reproduce sexually are an exception to this. Each parent's reproductive cells carry only *half* the normal number of chromosomes. When they unite (in a human, when an egg is fertilized by sperm), they form a single, complete cell with the full number of chromosomes. Half of the chromosomes (and their genes) come from one parent, half from the other. After this, the joined cell replicates normally.

As a multicellular organism grows, genes are activated to cause individual cells to specialize. Some become nerve cells, others become skin cells and yet others form different organs, et cetera – all in accordance with the instructions carried in their genes. In humans, a fertilized egg (*zygote*) develops first into a *blastocyst,* then an *embryo,* and finally a fetus that is eventually capable of surviving outside the womb as a baby.

Gengineering Techniques

Genetic engineering, or "gengineering," is the practice of manipulating genes to produce desired changes in an organism. The foundations of gengineering were laid in 1950s, when Watson, Crick, Franklin and Wilkins described the structure of DNA. Watson and Crick identified it with the basic blueprint of life (1953), and determined that all terrestrial life forms seemed to share a universal genetic code.

In the 1970s, it was discovered that proteins called *restriction enzymes* (derived from certain bacteria) could act like molecular knives, slicing DNA molecules at predetermined points, while another enzyme, *ligase,* could function like a molecular glue to rejoin these pieces. Since all life on Earth has the same genetic code, the genes are, in a gross but wonderful sense, a box of interchangeable parts. Using restriction enzymes and ligase, scientists found they could chop fragments out of one organism's DNA and splice them into another, resulting in "recombinant DNA." Thus the discipline of genetic engineering was born.

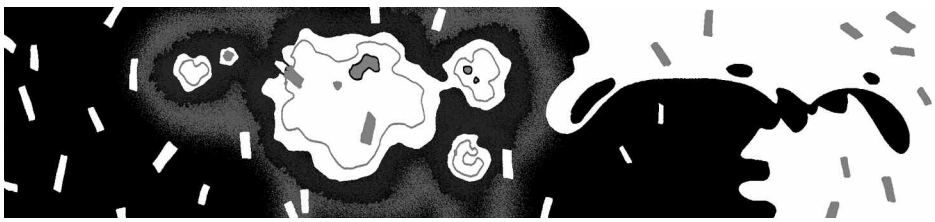
At first, only simple bacteria could be gengineered, but by the 1980s, scientists had learned how to "cut and paste" genes into more complex plants and animals. Since DNA is a universal code, genes from one species can be added to another, producing *transgenic* life forms that possess traits from multiple species.

By the 1990s, many transgenic life forms, from simple bacteria to higher mammals like mice and pigs, had been developed and even patented, for both research and commercial purposes. Ethical considerations have so far prevented the creation of transgenic humans, but human genes have been inserted into other organisms. Genetic engineering has also been performed on humans to fix genetic defects (such as immune deficiency or cystic fibrosis), using a process known as *gene therapy.*

So how does gengineering work?

Sophisticated chromosome-mapping techniques (see *Human Genome Project,* p. 14) are used to determine which genes do what. The desired genes can then be cut out of cells (using restriction enzymes) and placed into bacteria, where they are copied as the bacteria reproduce. Since the 1980s, however, the favored method has been a technique known as the *polymerase chain reaction,* or PCR; see p. 13. A genetic engineer can create a computer model of the genetic sequences he wants, then mix together the basic building blocks to assemble DNA molecules in the lab. By copying the sequences of existing genes, genetic engineers can produce genes that they know will be functional. Alternatively, they can analyze proteins and use that information to devise genes that will produce those proteins.

Strands of DNA don't do any good just sitting in a test tube, though. If the DNA is to be added to a different species, it must be further modified so that it will actually do something ("express itself") when inserted into the host organism's cells. To do this, genetic engineers must construct a partially artificial gene that obeys the regulatory mechanisms of the host species. Altered DNA also needs a way to enter the cells of the organism it is to modify. Some of the methods used by gengineers to accomplish this are:



Microinjection: A favored method is to *inject* genetic material into target cell nuclei, either with a tiny needle or by using a "gene gun" which uses compressed gas to fire very tiny pellets (often gold dust) coated with genetic material. Microinjection is the preferred method when genes need only be delivered to a single cell (such as a bacterium or egg cell) in a lab dish.

Bacterial Plasmids: Plasmids are small rings of DNA found in bacteria outside their chromosomes. Some types of soil bacteria, such as *Agrobacterium tumefaciens,* have the habit of inserting pieces of their plasmids into plants, transferring some of their DNA to the plant's chromosomes, resulting in tumors. Scientists have been able to modify these plasmids into vehicles for the transport of recombinant genes, and they are useful tools for gengineering many plant species. However, this method is ineffective on animals and some plants.

Retroviruses: In their natural state, *retroviruses* ("RNA viruses"), such as HIV, enter a living cell and take over its metabolism. They inject their RNA into the cell, taking over its cellular machinery and forcing it to make copies of the virus. Genetic

Prokaryotes and Eukaryotes

At the cellular level, a yeast is more closely related to a human than either are to a bacterium. Terrestrial life is divided into two main categories: *prokaryotic* organisms (like bacteria) and *eukaryotic* organisms (like fungi, plants and animals). The cells of eukaryotic and prokaryotic life forms have certain fundamental differences. For example, eukaryotic cells possess a clearly-defined nucleus, as well as possessing introns (see *Junk DNA and Gengineering,* p. 10) and organelles (see *Eve, Eukaryotes and Organelles,* p. 8).

While the two major branches of life on Earth are the prokaryotic bacteria and the eukaryotes, a third division has recently come to light. These are bacteria-like microorganisms that have been named *archaea* (meaning "ancient" in Greek), because they have been around on Earth for billions of years. When first discovered 20 years ago, these "archaebacteria" were thought to be a very ancient type of bacteria with odd properties; e.g., some archaea species have a methane-secreting metabolism and live in high-temperature thermal vents. However, recent research suggests that they are quite different on a genetic level – two-thirds of the genes of archaea do not resemble those of any other living creature, suggesting a divergence from bacteria at least three billion years ago.

Eve, Eukaryotes and Organelles

One of the major differences between bacteria (prokaryotes) and more advanced organisms (eukaryotes) is that the latter possess miniature, organ-like parts called "organelles."

Organelles are located outside the cell's nucleus, and perform specialized tasks, much like our body's organs. For example, the *mitochondria* are bundles of rod-like organelles where vital, energy-releasing chemical reactions take place. These energy factories consume oxygen to break down sugars and acids, then capture the resulting energy for the cell's use. Other types of organelles include *plastids* (organelles where photosynthesis takes place in plants) and *undulipodia* (whip-like bodies found in the tails of sperm).

Organelles resemble tiny bacteria – in fact, they possess minute amounts of their own DNA and RNA. In effect, they have their own tiny genomes. A growing body of recent evidence suggests that in the distant past, organelles were originally free bacteria, but were engulfed by other bacteria and incorporated into them as symbiotes. Our genetic code seems to show that it was this evolutionary leap that transformed prokaryotes into the more complex eukaryotic species, enabling them to evolve into plants and animals.

Organelles – specifically, the mitochondria – have helped scientists study the way species have evolved. When an organism reproduces sexually, the sperm and egg unite to combine the mother's and father's genetic information.

Continued on next page . . .

engineers have turned this ability to their advantage. They modify the retrovirus so that instead of hijacking the cell to make viruses, it deposits the new gene. One pitfall of this method is that viruses are hard to selectively target – this procedure often produces many failures for each success, and there is a very slight but real danger that the virus will deposit genes in the wrong place, or damage existing genes, resulting in unintended defects or even cancer. However, retroviruses have the advantage that they can be used to deliver genes to many cells at once, which makes them useful for gene therapy (see p. 9). In the future, "smarter" tailored viruses with greater discrimination may be developed.

Artificial Chromosomes: The problem of knowing where to put recombinant genes may be solved in some cases by creating completely synthetic chromosomes. This has been done in the lab (as of 1997) and may prove to be a useful tool. A new chromosome will be very obvious to any genetic test, though!

Nanoviruses: At present, retroviruses and microinjection are the most common ways of inserting genetic material. However, 21st-century gengineering may use more exotic techniques. One possibility is the *nanovirus,* a protein-based "organic robot" capable of performing sophisticated molecular and cellular engineering. Nanoviruses may be radically gengineered retroviruses or white blood cells, or completely artificial constructs. They pass harmlessly through cell membranes and take over cellular machinery using their own artificial enzymes, then alter or insert genetic material or other chemicals. They communicate with each other using specialized enzymes, and even cooperate, coordinating their operations. Nanoviruses are powerful tools, and are the basis of many ultra-tech gengineering projects, taking over from clumsier tailored viruses in tasks such as germline gengineering.

So what can you do with recombinant DNA? Some possibilities are . . .

Gene Cloning

Genetic engineering techniques can be used to isolate the particular gene that produces a given protein. That gene can then be inserted into a fast-reproducing bacterium, creating a transgenic species. What good is that? We'll demonstrate with an example:

The protein insulin is vital for treating diabetes. It's produced naturally in the human pancreas, but harvesting it from humans is not practical. Before gene cloning, insulin was harvested from other animal species, but this required expensive purification and sometimes had side effects. What was needed was a way to mass-produce pure human insulin in large quantities. This was accomplished by using recombinant DNA techniques to splice the gene that makes human insulin into a bacterium. If the genetic engineering is properly performed, the bacterium will accept the foreign gene. The human gene will then "express itself" by telling the bacterium to manufacture the desired protein.

Bacteria can reproduce every half hour or so if they are supplied with the proper nutrients and their temperature is carefully regulated. Each time they reproduce, they double their population; in a day, there might be a few million of them. When a large enough biomass of bacteria exists, the mass can be processed to extract the protein. A little more finesse in the genetic engineering may even produce a bacteria that excretes the protein itself. If a large enough vat is used, tons of commercially-useful proteins can be produced.

This process has been used successfully since the 1980s. While late-TL7 gene cloning techniques of this sort focus on compounds that are medically useful (such as insulin or growth hormones), TL8+ techniques may widen this to include numerous proteins with exotic industrial applications. As genetic engineering labs become more widespread, it's possible to imagine gene cloning being used to produce substances such as illegal drugs.

In addition to naturally-occurring, medically-useful proteins, gengineering has spurred the design of new ones with novel

characteristics, such as tailored enzymes designed to perform specific chemical reactions more efficiently than conventional catalysts. In the 1990s, only a few dozen enzymes were used for industrial purposes, such as detergents or food sweeteners, but enzyme engineering will be a major industry in the 21st century. Many future products, from superior plastics to new foods and wonder drugs, may use genetically modified ("genemod") enzymes in their manufacture, and such enzymes may even be the first step toward building nanomachines.

Germline Gengineering of Plants and Animals

This is what most people think of as genetic engineering. Using the techniques described above, genes are inserted into the reproductive germ cells of a plant or animal, such as fertilized eggs. Modifications to the single, fertilized germ cell will be passed on to all successive cells in the organism, as the egg cell grows and divides. Moreover, if the process is performed correctly, the altered genes will be put in the right places and be accepted by the cells' regulatory mechanisms. This will cause the cells to produce different proteins, which will lead to the organism developing in a different way than it otherwise would. The result? A permanent change in the species, and one that can be passed on to successive generations.

Germline gengineering can create enhanced or modified organisms. These include transgenic plants and animals with numerous commercial, medical or even military uses (see Chapter 4) and altered humans or other intelligent species (see Chapter 2).

Gene Therapy

When working with germ cells, a single change will spread throughout the entire organism. However, after a germ cell has grown from a seed or an egg into a mature organism, performing genetic engineering is much trickier, because instead of working with only one cell, the gengineer must work with billions, each of which has now been locked into a specialized role.

While it is very difficult to add genes that alter the way an organism has already grown, genetic engineering can be used to correct hereditary defects like cystic fibrosis or hemophilia, which are generally caused by malfunctioning genes in specific parts of the body. The process known as *gene therapy* uses retroviruses or other methods to replace defective genes with functioning ones in specific cells. In the future, with the availability of more advanced tools like nanoviruses, such "genetic surgery" may become a means of not only healing but also augmenting or transforming living beings – see *Genetic Surgery* (p. 75) and *Proteus Viruses* (p. 77).

Genetic Testing

Everyone's DNA is unique (with the exception of clones and identical twins); a genetic record is contained within every cell. A person's DNA will also be similar to his blood relatives', and so can be used to help determine one's ancestry.

At present, it's possible to perform genetic tests on blood or tissue samples. In the future, as the human genome is mapped and sequenced, the accuracy of these tests and the amount of information they will provide will continue to increase.

Genetic testing has a wide variety of applications. These include:

Trait Analysis: By matching a person's DNA sample against what is known of their species' genome, hereditary traits can be determined, including sex, race, hair and eye color, hereditary diseases, et cetera. By mid-to-late TL8, even more detail may be available, as the Human Genome Project (p. 14) turns up the genes that influence specific mental and physical traits – or even psi or super powers, in settings where those have genetic causes! In general, if an advantage or disadvantage is inborn rather than otherwise acquired, it may be detected by trait analysis.

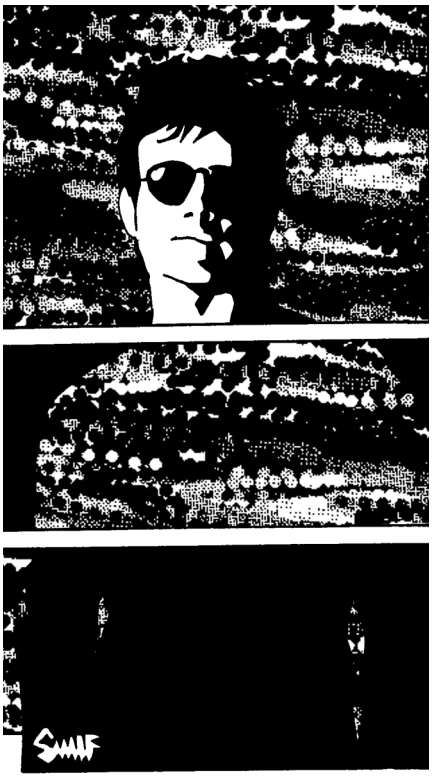
Identification: A quick genetic test can be used for on-the-spot identity checks, comparing a blood (requires only a pinprick) or saliva sample with information that is contained on an ID card or in a database. This may be common in

Eve, Eukaryotes and Organelles (Continued)

However, the sperm only carries a nucleus – it doesn't transmit any of the father's mitochondria, which are outside the nucleus. This means that mitochondrial DNA is passed on only through the mother. By measuring the rates of genetic mutation over generations – which, in the simple genome of mitochondria, are remarkably regular – it is possible to get estimates as to how old a particular species is, and at what point it diverged from other, related species.

In 1987, a team of scientists used this "mitochondrial clock" to develop the "Eve" theory. Study of different human populations allowed them to calculate an average mutation rate for human mitochondria, and they used that to conclude that the ancestor of all surviving mitochondrial DNA types existed around 200,000 years ago, in Africa. This doesn't imply there was only one human female – only that, of several thousand early humans, only one particular African genetic line has survived. For more on the "Eve" theory and its relevance to human evolution, see ***GURPS Dinosaurs***, p. 94.

The "Eve" theory is still quite controversial, and there are questions about the accuracy of the statistics used in the calculations. Nevertheless, as our knowledge of genetics improves, this kind of genetic analysis may prove to be a valuable tool in measuring the way species evolve.



high-security areas. However, considerations of privacy may lead to laws that limit the widespread use of genetic identification.

DNA Forensics: Analysis of trace DNA samples – such as remains, or bodily fluids left on a crime scene or victim – can be matched with genetic records in a database. This can identify who was involved. If no match comes up in the databases, suspects can be tested. Trait analysis can also be performed, and may provide clues as to the identity of the perpetrator or unidentified victims. At mid-to-late TL8, genome information can even be used to create a rough computer simulation of what the subject might look like (in the absence of cosmetic surgery) assuming various ages and environmental influences, such as diet.

Genetic Targeting: At high TLs, DNA information may be used to create target-seeking diseases (p. 89) or nanoviruses (p. 84) that can home in on specific individuals.

Testing Procedures

Genetic testing at TL7 must be performed in a laboratory. Forensics skill and a day or more of work may be required to properly gather samples. Genetics skill and at least three hours will be needed to compare the DNA of one suspect with another; commercial labs usually take about six weeks to report. Trait analysis requires at least a day's work. Critical failure can result in the contamination and misidentification of samples. If samples are very small (e.g., only a tiny trace of blood), apply a -4 penalty. A rush job (3-4 hours) is made at a -2 penalty; there is no modifier for taking a full day, while taking a full *week* gives +2.

At TL8, a *portable genetic scanner* can take samples in a few seconds (prick a finger, for instance), analyze them and upload the data to a computer for an instant cross-check against a database. A pocket scanner is $500 and one pound at TL8; roll vs. Electronics Operation (Sensors)+2 or Forensics+2 to use it. An expert system program capable of performing on-the-fly genetic trait analysis (at skill 10, takes about ten minutes per attempt) is Complexity 3 and $50,000 at TL8. Each +1 to skill doubles cost and increases Complexity by one. All weights and prices are halved one TL later, and halved again two or more TLs later. People like police officers will usually be able to connect their personal computers to computers running multi-million dollar, high-Complexity programs in major facilities (e.g., FBI crime labs) for rapid analysis.

At TL9+, *bioscanners* (p. UT19) can perform genetic scans. As well, forensic microbots – or nanomachines, at higher TLs – can be introduced into a crime scene to locate nearly all traces of blood, tissue and other evidence in a few hours. These can uncover traces dating back weeks or months. A package of forensic microbots or nanobots is $2,000. See p. UTT83 for more information on forensic nanomachines.

Genetic Testing and Privacy Issues

Whose genetic records end up in a genetic database, and who are they accessible to? This is a major legal question for the 21st century.

Currently, most genetic testing is done by hospitals, at the request of patients who want to see whether they have any hereditary defects, usually because there is a history of such problems in the family and they are considering having children.

Some genetic testing is also performed under legal auspices, generally for forensic purposes – especially in rape cases, and to determine parentage in custody or paternity suits. At present, genetic testing usually requires a search warrant, or may be administered on a voluntary basis to prove one's own innocence.

For the moment, only people who have undergone these tests end up in law-enforcement genetic databases. In the 1990s, the FBI had DNA profiles on over 100,000 people, mostly prisoners. Meanwhile, the U.S. Army is genetically testing its personnel and developing portable scanners. The announced purpose is to make it easier to identify the remains of dead soldiers.

The question of whether employers can test workers or job candidates is controversial. For example, current genetic tests can determine susceptibility to some hereditary diseases. If testing showed that someone had a greater-than-usual risk of developing medical problems (even late in life), then they might be perceived as a potential burden on corporate health care plans. There is also the risk of lost productivity if they get sick.

Junk DNA and Gengineering

Genes that make proteins used by the body only account for about 2% of the genetic material on the chromosomes of most species. Much of the rest are regulators for control sequences which tell the genes when to turn on or off. In eukaryotic organisms (such as humans) there are also *introns* – long, seemingly meaningless "junk DNA" sequences with no apparent function. Eukaryotic cells possess mechanisms to ignore the intron sequences when making proteins.

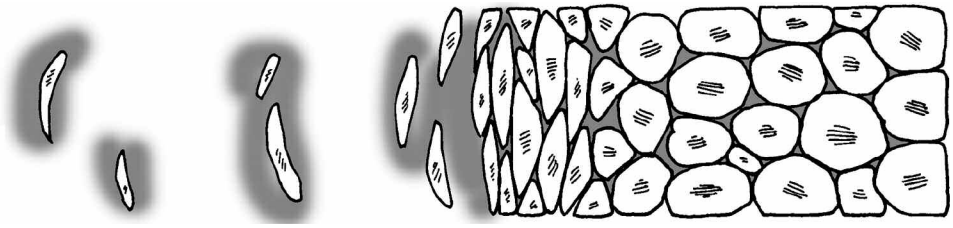
How did these "worthless" introns get into the genetic code? One theory is that they represent changes introduced by ancient viral hitchhikers, or are simply the genetic debris of evolutionary dead ends. It's also possible that they act as "genetic speed bumps" to slow down and regulate the rate at which certain proteins are manufactured. Maybe they act as genetic "spare parts," usable in future mutations. In a cinematic campaign, introns may have a more sinister purpose – they could contain latent genetic sequences that await the proper control signal to activate. Perhaps they would express themselves as superpowers!

Continued on next page . . .

As a result, they might not be hired, and might even lose *existing* jobs or health insurance. Similarly, insurance companies may wish to test applicants. As testing gathers more data on genes that influence human behavior, discrimination could be extended toward people with hereditary tendencies toward "undesirable" mental traits.

Other issues related to genetic testing include the screening of the unborn: If an embryo or fetus tests positive for a birth defect – or just isn't up to par – should it be aborted? Or should genetic surgery be attempted? Then there's the question of whether a person would *want* to know that he has a higher risk of coming down with a disease – or that his genes say he has less potential for intelligence or mental stability than is the norm. Finally, there are worries about the security of genetic information. If a cautious couple get tested to ensure they won't pass on hereditary conditions to their children, can they be sure that their genetic data won't also find its way to insurance companies or employers?

Just *how* widespread genetic testing becomes may vary from country to country, and in a ***GURPS Space*** campaign, from planet to planet. In many countries today, there is political support for laws to limit testing in order to protect genetic privacy. In a "dark future" like ***GURPS Cyberworld,*** though, these may be repealed to serve the interests of megacorporations and repressive governments.



Genetic Reconstruction

This is a technique in which traces of genetic information – even minute DNA fragments – are recovered and pieced together with the help of technologies such as the polymerase chain reaction (p. 13). Computer synthesis and extrapolation from the genomes of known similar organisms, if any, can be used fill in the gaps left by damaged or missing DNA. Eventually, enough genetic material may be available that an entire genome can be reconstructed. It can then be studied in the lab, or possibly even spliced into a reproductive cell from a similar species (if one exists) and carried to term, either within an artificial womb or a suitable surrogate mother.

Genetic reconstruction is a powerful research tool for determining the nature of vanished species. More dramatically, it may be used to reclaim species that have recently become extinct. At higher TLs, long-dead species, such as mammoths, dinosaurs or even a vanished race of aliens, could be reconstructed from fragmentary evidence, provided that such evidence could survive.

DNA has been recovered from specimens of humans, plants and animals many thousands of years old that have been mummified, frozen in glaciers or preserved in peat bogs. The chance of finding DNA traces from creatures millions of years old, such as dinosaurs, is more remote. Michael Crichton's *Jurassic Park* portrays a scenario where dinosaur DNA is found in amber, preserved inside the stomach of an ancient mosquito that had sipped dinosaur blood before becoming caught in tree sap. However, even if such a find were made, it would be nearly impossible to assemble the trace DNA fragments that would be recovered into an actual genome, at least with present technology.

If actual tissue and bone samples are available, the process is far simpler – rather than bringing back dinosaurs, we may want to start with more recently extinct animals. Forensic investigators could also use this technique to make a genetic map of a decades-old corpse, then check it against their files. If they had no records of a person with that genetic pattern, they could call up a holographic computer simulation to determine his original appearance . . . or even clone the body! (A reconstructed clone would have the mind of a newborn, although there is nothing to prevent a braintape being played into one; see p. 116.)

Junk DNA and Gengineering (Continued)

If genetically-engineered critters are manufactured from scratch (TL9+), the designer may decide not to include introns, to make his task simpler and the results easier to predict. This means that gengineered organisms may have highly-compact genomes. This would be a good way to tell if a blood sample is from an evolved organism or a manufactured one. Of course, without all that "junk" to work with, there will be very little chance of novel traits developing spontaneously.

One "far out" use for introns would be to code non-genetic information into an organism's cells. For example, trademarks, serial numbers, secret messages or other data could be "written" into an organism using coded arrangements of introns! And what if ancient astronauts coded an interstellar "treasure map" into *our* introns?

Viruses and Bacteria

A *bacterium* is a single-celled, microscopic prokaryote, of which there are countless different species. Bacteria are the simplest forms of life, capable of rapid reproduction by dividing to form more bacteria.

A *virus* is much smaller – too small to be seen under the average optical microscope – and consists of a clump of genetic material (DNA or RNA) sheathed in protein. By some definitions, it's not alive at all. Viruses grow only in living cells, whereas certain strains of bacteria can survive almost anywhere. A virus lacks the molecular machinery to reproduce itself, such as the ribosomes that cells possess. Instead, a virus seeks out living cells, slips into them and hijacks the cells' machinery into working for it.

A *retrovirus* is a virus whose genetic material consists of RNA. This type of virus can be relatively easily modified into a tool useful in gengineering. For instance, genetic engineers can create modified "transfer" viruses that can carry new genes (or gene regulators) into cells in order to alter them.

A *nanovirus* (p. 77) isn't a real virus – it's a bio-nanotech construct that sometimes behaves like a virus. It might have a virus in its ancestry, but its relationship is about as a close as that of a wooden ship to a tree.

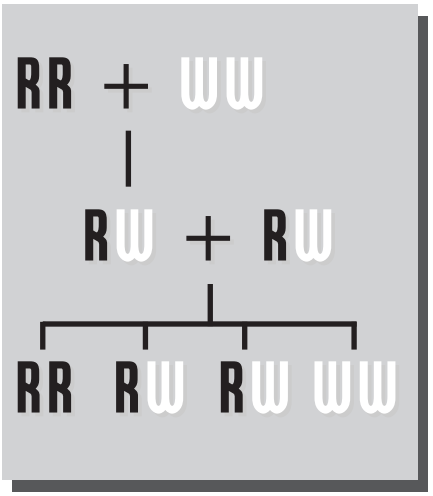
Heredity

In the nineteenth century, a monk named Gregor Mendel studied pea plants. He postulated that each inherited trait (like whether a plant is short or tall) is determined by a specific factor, which we now call a *gene*. An organism has two copies of each trait's gene. In reproduction, each parent passes half of its genes (determined semi-randomly) to its offspring. The other half come from the other parent.

For example, flower color in plants is a genetic trait. If one plant has red flowers and the other has white, will the flowers of their offspring be pink? No! This is because those genes don't blend together. Instead, the offspring of a cross between white and red parents would also be either red or white. Which gene is obeyed depends on whether that gene's trait is a "recessive" or "dominant" one. If red flowers were dominant over white for a particular plant, then the hybrid offspring would be red.

However, that isn't the end of the story. While the hybrid plant *looks* red (this is called its *phenotype*) its actual genes covering color (or *genotype*) are a mix of one for redness and one for whiteness. Suppose it is cross-pollinated with another red hybrid that has one red and one white gene. The luck of the draw may lead to their offspring having two red genes (thus being red), a red and a white gene (also red), or two white genes (white!). Thus, two plants with red flowers can produce one with white flowers.

Continued on next page . . .



If a scientific lab is hired to perform a genetic reconstruction, the process will usually take from two to six weeks (depending on the difficulty) and cost $5,000 per week.

If a scientist wants to attempt a reconstruction, the GM first determines if there is enough genetic material to make it possible. Reconstruction requires a genetics lab, a Genetic Replication computer program (Complexity 6, $40,000) and a successful Genetics roll. Suggested modifiers: -10 for DNA traces, -5 for actual tissue, 0 for a complete corpse; -15 at TL7, -10 at TL8, -5 at TL9, or 0 at TL10+. Roll each week; success indicates the process succeeded and a clone can now be made. A failure requires further work (one week times the number the roll was failed by). A critical failure indicates a mistake; an attempt to grow a clone will produce a *flawed* copy, a dead, non-viable one, or (possibly) a monster – GM's option.

Biomimetics

Biomimetics is the branch of materials engineering that deals with the development of synthetic designs modeled on biological materials. Natural materials often have extremely complex molecular structures. Rather than copying these directly, biomimetics seeks to improve on nature by using them as templates for synthetic molecular designs.

Designing synthetic versions of natural polymers – like snail shells, wood or insect chitin – could lead to stronger and tougher materials. As well, since many biomaterials can sense and respond to their surroundings, a major goal of biomimetic technology is to develop "smart" materials capable of altering texture, color or shape, sensing and repairing stress and damage, or even growing. Primary applications include armor, cybernetics, sensors, textiles and waterproof, weatherproof, "chameleon" or "stealth" coatings.

Many of the TL8+ items in ***GURPS Ultra-Tech*** already employ biomimetic materials. The most obvious is bioplastic (see p. UT17), but more subtle applications also exist. For example, some archaebacteria (see *Prokaryotes and Eukaryotes,* p. 7) live at very high temperatures in ocean thermal vents. Their heat-stable molecules could be adapted for many industrial and pharmaceutical processes, ranging from detergent additives to ablative armor (p. UT73). A more widespread biomimetic technology is "bioglue" – a range of a biodegradable, waterproof adhesives based on the naturally-secreted, protein-based glue used by limpet mollusks. Bioglue can be found in many TL8+ surgical kits, replacing conventional surgical sutures, since it does not need to be removed; it is also the adhesive base for plastiskin patches (p. UT94). Besides its medical uses, bioglue is used to assemble many TL8+ composite materials and in ultra-sticky tangler strands (p. UT51).

Biotronics

This technology uses organic, protein-based systems rather than inorganic molecules for information storage and processing. Some biotronic technologies on the horizon are . . .

Biosensors (TL7/8)

A *biosensor* is an electronic device that consists of a ordinary computer chip coated with a layer of biological molecules that selectively bond with a specific, known compound. When this occurs, the chip sends a signal that these molecules are in the area. Depending on the design, a biosensor can be used as a contact sensor to identify specific chemicals or biological substances, or as a ranged sensor to detect airborne molecules such as toxic gases or explosive vapors.

The main limitation of biosensors is that they don't detect "unknown" compounds. However, they can be easily updated by plugging in a new biosensor chip. At TL8+, more sophisticated biosensors may work as "electronic noses" with bloodhound-like odor detection capability. For an example of a biosensor, see the chemscanner (p. UT19).

Optical Biochips (TL8)

Bacteriorhodopsin is a natural protein derived from bacteria. When illuminated, it absorbs light and undergoes predictable and rapid chemical changes. Bacteriorhodopsin may be stabilized into two-dimensional lattice structures that function as optical switching systems on a much smaller scale and with higher information density than silicon-based electronics. Biochips using bacteriorhodopsin lattices or similar protein-based information technologies may provide the integrated computing power necessary for many TL8-10 gadgets, such as minidisks, computer chips, optical data storage, holographic technology, "rollable" video displays and datacloth (p. UTT32), miniaturized HUDs, cyberwear (especially bionic eyes), microbot brains (p. RO67) and "smart" textiles such as varicloth (p. UT27), chameleon suits (p. UT85) and intruder suits (p. UT86). They are also a vital precursor to nanotech.

Vatbrain Biocomputers (late TL8)

A vatbrain, or "meat matrix," is a computer whose processing capabilities have been enhanced with organic nerve tissue. Due to their ability to mimic human neural systems, vatbrains are highly efficient. The down side is that the life-support facilities for their organic central processing units are heavy, requiring precise environmental controls and nutrient feed systems. Some experimental models may be too delicate for commercial use, but spin-offs of biochip systems and cyberbrain technology may remedy this.

Vatbrains are constructed using the computer rules found on pp. CII12-15. They *must* have the neural-net option. In addition, weight and volume are multiplied by 1.5 and cost is multiplied by 5. They have +1 Complexity.

A vatbrain of Complexity 7+ can spontaneously "awaken" and become sentient. Roll 3d each year. On a 6 or less, the computer awakens; see p. UT31 or p. RO57 for the effects. A good example of a sentient vatbrain is Memnon-12 (p. CW92-93), a TL8 macroframe with the neural-net and vatbrain biocomputer options that has put extra character points into IQ and skills.

DNA Computers (TL9)

This technology makes use of the amazing information density of DNA. By modifying its strands to form a half-dozen or so branches, "computing cells" can be linked together into a complex "bio-net" matrix. Data is then stored as electrons in metallic atoms bonded to each cell. A DNA memory unit the size of a sugarcube could store *terabytes* of data, while cell-sized DNA computers could control microbots or nanomachines such as the nanoviruses used in gengineering and nanosurgery.

Will DNA computers be the wave of the future, or will they be replaced by advanced optical storage or inorganic nanocomputers? It would be reasonable to assume that TL9+ computers *are* DNA computers – and just as reasonable to assume that they use other techniques – so it's up to the GM. However, if DNA computers do fulfill their promise, it would be quite realistic to increase the data storage of both "disks" and mass storage by a factor of 1,000 – that is, read "gigabytes" (gigs) as "terabytes."

Heredity (Continued)

Recessive traits can skip generations, which is why you sometimes see children who *don't* resemble their parents. In humans, many rare traits, including most inherited genetic defects, tend to be recessive.

In practice, heredity is actually a lot more complex than the "ideal" Mendelian model – there are mixed-dominant, cross-dominant and non-Mendelian traits that break the rules described above. Some traits are also "sex-linked" – that is, they are located on sex chromosomes, and are transmitted differently between males and females.

In many science fiction novels that deal with psi abilities (notably Frank Herbert's *Dune* and Marion Zimmer Bradley's *Darkover* series), recessive and sex-linked traits are often used to explain why certain psi powers are rare, or why women or men are more likely to manifest them.

Polymerase Chain Reaction (PCR) (TL7)

One of the basic tools in any genetics lab since the late 1980s is the polymerase chain reaction (PCR) machine. This can rapidly replicate ("amplify") DNA from very small amounts of source material in a matter of hours, creating thousands of copies of DNA fragments from single cells. Besides its use in genetic engineering, PCR allows genetic testing from as little material as a hair follicle or a tiny drop of blood (see *Genetic Testing,* p. 9), permits the automation of gene sequencing (hastening efforts like the Human Genome Project, p. 14) and allows genetic reconstruction (p. 11), enabling researchers to isolate and replicate ancient DNA samples.

One weakness of PCR is that it is so sensitive, technicians must use great care to ensure that whatever DNA they are amplifying actually comes from a particular sample, rather than contaminants – say, a skin flake from the researcher.

Continued on next page . . .

Polymerase Chain Reaction (PCR) (TL7) (Continued)

All late TL7+ genetics labs include PCR machines or their ultra-tech equivalents. On their own, PCR machines may cost from $3,000 to $125,000, depending on their speed and capabilities.

The Human Genome Project

The complete set of instructions for making a particular organism is called its *genome*. It exists in the nucleus of every cell, and acts as the blueprint for all cellular structures and operations.

The Human Genome Project is an international endeavor to discover the 50,000 to 100,000 human genes (the human genome) and determine the complete sequence of the three billion DNA subunits (base pairs) that make them up. The full project was underway by 1990. The project was intended to be finished around 2010, but recent advances in automated gene sequencing and parallel computing may result in early completion, between 2001 and 2005.

Currently, about 4% of the total genome has been mapped. However, a major preliminary part of the project has been the development of technologies for rapid DNA mapping and sequencing, and it is expected that as these mature, the pace will pick up exponentially – which it seems to be doing. It will be much easier to map the genomes of other animals. In fact, parallel projects to do just that are already being carried out.

Conservative predictions involving no new technologies suggest that the completion (or even partial completion) of the project will bring the ability to cure many or all genetic diseases via gene therapy (p. 9). It will also allow very precise genetic testing, which may have considerable social impact (see *Genetic Testing and Privacy Issues,* p. 10). Human genome mapping will also make "DNA fingerprinting" much simpler and more precise, with major applications in forensics in particular and identification technology in general.

In the long term, genome mapping is a necessary precondition for advanced genetic engineering. It is the key to understanding the structure, organization and function of DNA in chromosomes.

Continued on next page . . .

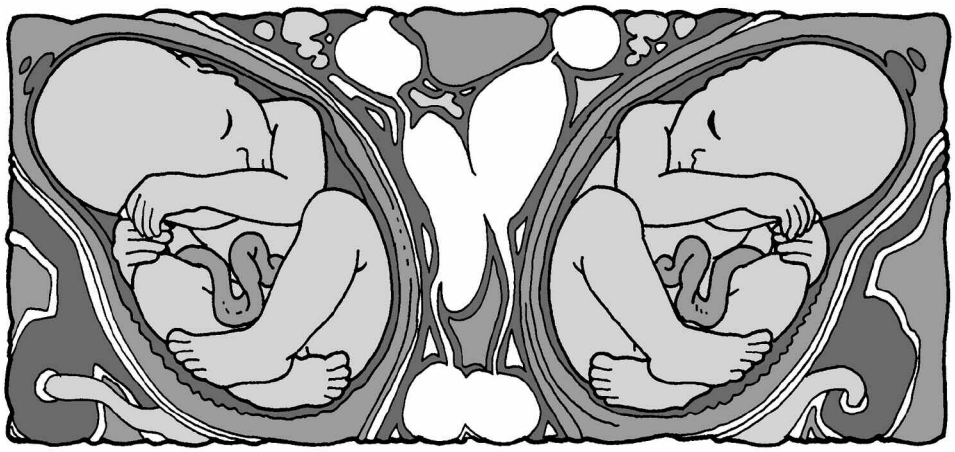
Cloning of Multicellular Organisms

Unlike bacteria, species that reproduce sexually receive chromosomes from both parents, and each child is different. *Cloning* is a way around this. It is a bioengineering technique that is used to produce multiple, genetically-identical offspring.

Cloning is easy with plants – it's done by making a cutting and planting it. Farmers and gardeners create clones all the time. It's not so easy with animals, but it is possible.

Much of the current research into cloning is driven by its commercial potential. For example, a prize cow or a superior strain of wheat can be reproduced exactly. Combined with gengineering, cloning allows genetically-engineered species to be mass produced, even if the gengineering was so extensive that they could no longer interbreed with normal specimens. The uses of human cloning are discussed on pp. 16–17.

Embryo Division (TL7): Another way to produce identical copies is to split an embryo at the 2-, 4-, 8- or possibly 16-cell stage to produce artificial twins, quadruplets, et cetera. While this isn't true cloning, it is considerably easier to do. It has been done with humans, but has little practical use.



Cloning from Embryonic Cells (TL7)

Cloning technology was first explored in the mid-1960s with frogs and fish, whose egg cells are very simple in design. These early clones were made by transplanting the nucleus (containing the chromosomes and genes) of an embryonic animal cell into an egg cell whose genetic material had been removed. With electrical stimulation, the modified egg then developed normally into an embryo, a fetus and finally a baby, genetically identical to the nucleus donor.

However, while scientists could make clones, there seemed to be a catch – a process known as *cell differentiation.* As an embryo develops into a fetus, certain genes in each particular cell activate, depending on the cell's role in the developing organism. The cells become much more specialized; for instance, they turn into skin cells, heart cells, brain cells and so on. The unused genes "switch off," and the now-specialized cells lose the ability to replicate in the fashion that cloning requires, because the genes required to make a complete animal are no longer functioning. The only way to avoid this problem seemed to be to take a cell from the early embryo (a *stem cell*), before it had differentiated.

During 1980s and 1990s, cloning experiments were applied to mammals. Human embryos were first cloned in 1993, but they were not allowed to develop into fetuses. Researchers figured out how to make multiple clones by culturing several cells from the same embryonic cell, but this had limited usefulness. You could clone animals like livestock, but because you'd have to start with the embryo, there was no way of knowing whether the animal would be worth cloning. As for cloning humans, you'd have to make the decision to clone before someone was born! There seemed to be no way to clone an adult, a child or even a fetus.

Cloning from Post-Embryonic Cells (Late TL7)

This is *adult* cloning. Take a DNA sample from anywhere (skin, breast, blood, et cetera), load it into an egg whose DNA has been removed, and grow it into a baby who is a perfect genetic copy of the original cell donor. It seemed like an impossible dream – but in 1997, Scottish scientists led by Ian Wilmut proved that the impossible wasn't: Dolly, a female sheep cloned from adult cells, was born!

How is this accomplished?

First, cells (in the case of Dolly, udder cells) are removed from an adult animal and allowed to replicate in nutrient dishes. Then, the nutrients are scaled back dramatically, and the starving but still-living cells become quiescent. This crucial additional step of making the cells inactive is enough to allow their genes to receive signals to start making an embryo, given the correct environment.

This environment is provided by an egg taken from a female of the same species (who can also be the cell donor). Using techniques similar to embryonic cloning, the nucleus of the unfertilized egg is scooped out, removing the genetic material but leaving the rest intact. An electrical spark is used to fuse the quiescent donor cells with this egg, "awakening" the cell. The egg and nucleus then begin to form embryonic cells; about a week later, they're ready to be implanted into a surrogate mother. The offspring that results is a clone of the original cell donor, with no relation to the egg donor or the surrogate mother.

While cloning of adult organisms is now a reality, there are still some real and potential problems with the technology:

Inefficiency: The methods used to produce adult clones at late TL7 are very difficult and labor intensive. In Dolly's case, out of 277 attempts to fuse adult cells with eggs, only 13 pregnancies resulted, and only one was born alive. Nevertheless, it seems likely that the odds will improve if further research and development are financed. In ***GURPS,*** we assume that further research into cloning and artificial wombs at TL8 will improve the success rate and reduce the cost.

Side-Effects: Adult cloning appears to produce an healthy organism, but it may take years to be certain. For example, there has been speculation that the cells of a cloned organism – taken from an adult – might "wear out" faster, resulting in premature aging. ***GURPS*** assumes this won't be the case – or if it is, that it will be overcome by more research. If the GM wants to use this concept, it could be simulated by giving clones disadvantages such as Short Lifespan or even Self-Destruct (p. CI104). If so, the age of maturity won't be any lower, but afterward, aging will occur more rapidly.

Sheep vs. Humans: Sheep embryos have some differences from human embryos in their early development that may make them easier to clone. The method used to clone sheep is expected to work on animals like cows, but it remains to be seen how difficult it will be to clone a human using these techniques.

Clones and Uniqueness

Genetically, a clone is much the same as an identical twin. A newborn clone will be a baby, without any of the original person's memories or skills. Various forms of ultra-technology may change this – see *forced-growth tanks* (p. 19) and *braintaping* (p. 116).

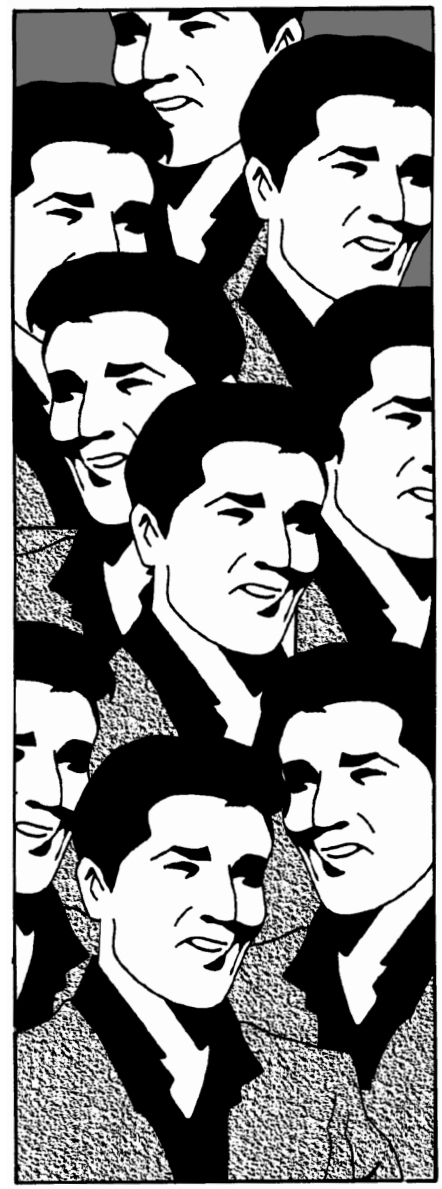
All other factors being equal, a clone will have an identical physique and appearance to the original. A clone is physically the same as the original at the same stage in its life. Thus, a 9-year-old clone will look just like the original did at age 9. While a clone will not have the original's memories, it will share any genetic influences on body and mind. In game terms, this means it will have any advantages and disadvantages that the GM rules are genetically inherited, and should have similar attributes to those of the original at the same age.

However, everything is not always equal. Diet, exercise and environment can have a dramatic affect on characteristics, from looks and build to behavior and intelligence. These changes can begin even before the clone is born. For example, if the clone is carried by a healthy surrogate mother, but the original was born to a mother

The Human Genome Project (Continued)

Genetic Differences

How similar *are* the genes of humans and other animals? All mammals have about the same number of genes, about 50,000 to 100,000. Within the DNA sequence – the arrangements of nucleotides – ape and human genes differ by less than 10%. For non-primate mammals, like cats or mice, the difference is about 20-30% overall. Physical differences are the result of very subtle changes in the nucleotide sequences that make up the genes. These in turn produce somewhat different proteins which interact with each other, producing the cellular differences that add up to spell "human," "mouse" or "cat."



Examples of Biomimetic Products

Two examples of biomimetic products of use to adventurers:

Arachnoweave Armor (TL8)

Armor created using an exotic biomimetic synthetic based on spider-silk proteins. Strong yet supple, "arachnoweave" armor is manufactured in black, gray or green for military or combat applications. It is also sold in various bright silk patterns for sportswear:

Light Arachnoweave PD 1, DR 4 (PD 0, DR 2 vs. impaling); $400, 0.5 lb. for vest; $500, 1 lb. for full suit.

Medium Arachnoweave PD 2, DR 8 (PD 1, DR 2 vs. impaling); $600, 1 lb. for vest; $800, 2.5 lbs. for full suit.

Heavy Arachnoweave PD 2, DR 12 (PD 1, DR 2 vs. impaling); $800, 1.5 lbs. for vest; $1,000, 4 lbs. for full suit.

As with Kevlar and monocrys, any 6 rolled does one point of crushing damage, even if the attack does not penetrate armor.

Biosensors – Chemsniffer (TL8)

A hand-held biosensor system. Devices of this sort are often used by customs officials or police to detect contraband, such as drugs or explosives, by analyzing traces in the air. It's typically equipped with a range of biosensor chips for 100 standard chemical compounds. Use Electronics Operation (Security Systems) to operate it; the device has a five-yard range. If contraband is completely sealed in airtight containers, the sniffer will be ineffective; however, careless loading may have left residues on the outsides of the containers. A chemsniffer costs $700 and weighs 2 lbs. It operates for 6 months on a B cell.

who was malnourished during her pregnancy, the clone may well grow up to be both taller and healthier!

If forced-growth tanks (p. 19) are available, they may be able to regulate the fetal environment to ensure that a clone *is* identical in appearance to the original, assuming this is desired. Without this technology, ensuring that a clone is completely identical requires ensuring that the clone's nurture and environment – from womb onward – simulate the original's. In some cases, this may require exhaustive research into the original's childhood.

Clones and Identification

Clones (and identical twins) may look alike, but fingerprints, palm prints, freckle patterns and retina prints will not match, at least not without surgical modification.

Also, organelles (see p. 8) like mitochondria exist outside the nucleus and thus come from the *egg donor,* not the genetic donor. Thus, unless the egg cell and the mature cell nucleus are donated by the same person (who'd have to be female), the clone won't be *exactly* identical – there will be slight differences in the tiny genome of the mitochondria.

Cloning Costs and Times

Today (late TL7), cloning is still experimental – some estimates place the cost of making an embryonic clone at about $50,000–$150,000, while a post-embryonic clone (like Dolly) might cost $750,000. If cloning is commercialized, prices should drop dramatically. Suggested prices and times for cloning mammals are:

Post-Embryonic Cloning: At early TL8, a biotech facility will take 1d weeks (allowing for failures) to clone a tissue sample, at a cost of $10,000 per week. This drops to a flat $1,000 and one week by late TL8, halved at TL9 and again at TL10. The result is a cloned embryo, which must be either implanted into a surrogate mother or grown in an artificial womb, such as a growth tank or forced-growth tank. See *Reproductive Technology* (p. 17) for these procedures.

Embryonic Cloning: Divide the cost by five if cloning embryonic rather than fetal, child or adult cells.

Assuming human cloning is legal, prices and times for cloning animals and humans will be similar. At TL8+, many hospitals and biotech labs will be willing to bank a customer's cell samples in a secure freezer for later use. This costs $100 a month.

While other ***GURPS*** books have coupled cloning technology with the idea of rapid growth (making an adult in six weeks, for instance), cloning and the forced growth of early embryos into adults are *not* the same technology by any means. At present, we know how to clone from adult cells, but the result is a baby – and the technology for both artificial wombs and the rapid growth of embryos is likewise in its infancy.

Cross-Sex Clones (TL8)

Chromosome manipulation may be used to change the sex of a clone, while keeping it more-or-less identical otherwise. At mid-TL8, this takes about a week of effort and costs $20,000 for a male-to-female change or $70,000 and an extra two weeks for a female-to-male change (this requires the creation of an artificial Y chromosome, which is tricky).

Clones as Spare Parts

One difficulty with transplants (p. 65) is the problem of tissue rejection. If human clones can be grown, they could be used as a source of medical transplants for the original, with no chance of rejection. (This also applies when transplanting parts from the original *to* his clone, as in a brain transplant.)

One clone can provide a complete set of organs. These can be left in the clone (with it gradually going over to life support as more bits are removed) or removed and preserved separately. The most radical procedure would be to transplant your adult brain into a younger clone body, or better still, use mind transfer technology (see *Braintaping,* p. 116) to upload your memories from an aging body into that of young clone of yourself!

In some societies, the ethical issues of growing humans for spare parts may prevent this technology from being developed. In others, it may be enough to simply keep a person's clone comatose, or lobotomize it, so that its mind never develops.

Even so, the cost of making a clone and maintaining it on life support is high – see *Cloning Costs and Times,* above, for the cloning operation itself, and *Growth and Forced-Growth Tank Fees* (p. 20) for the cost of actually growing or maintaining a clone. Thus, this technology may be something that only the rich can afford, unless society itself gets wealthier. This could lead to a two-tiered medical system, where the wealthy use cloned organs (or high-end bionic parts) and the poor use each other as tissue donors.

Vat-Grown Organs and Parts

While growing a clone as a source of spare parts may be too ghoulish for society to contemplate, there is an alternative. Advances in tissue engineering may make it possible to grow organs from cell cultures in vats or on biodegradable scaffolds, *without* the need to clone an entire human. Initial developments in tissue engineering should enable kidneys, livers, ears, noses and possibly genitals to be vat-grown by early TL8, taking about four weeks. However, independently growing other organs and body parts (like hearts, lungs, eyes and limbs) is more complex, and may require "whole body clones" until late TL8. This means that an organ shortage may still exist. For more details (prices, et cetera) on organ replacement, see *Medical Transplants* (p. 65) and *The Organ Trade* (p. 129).

Reproductive Technology

So the bioengineer has performed germline gengineering, or has just finished cloning. What next?

If his subject is a microbe, plant, or egg-laying amphibian, fish, reptile or bird, it's pretty easy. All he needs is a petri dish, some soil, a pond or an incubator like those used for chickens. However, higher animals that bear live young have special requirements. If that genemod egg sitting in a test tube is to grow past the stage of an early embryo, into a fetus or beyond, then it's going to need the right environment – a womb.

There are two major choices here. First, the egg can be implanted into a living being – a surrogate mother (maybe the original mother, if the egg came from her before modification). Second, it can be brought to term in an artificial womb.

Monoclonal Antibodies (TL7)

These are a good example of a "bioproduct" produced by gengineering. Ordinary antibodies are manufactured by specialized "B-cells" in the lymph nodes (including the spleen) and the blood. They are a vital part of the body's immune system, seeking out and attaching themselves to intruders such as microbes, viruses or foreign proteins. This alerts the rest of the immune system (white blood cells, for instance) to attack.

There are millions of different kinds of antibodies. Each is specialized to detect one particular type of unwanted organism. Antibodies are carried along in the bloodstream, ignoring everything else until they run into their targets. They recognize them because each molecule has its own particular, unique physical contour. Each antibody is shaped to match puzzle-fashion with its target molecule, so that when they accidentally run into one another, they will lock together.

Recently it has proved possible to clone specific antibodies outside the human body, using genetically-modified cancer cells ("hybridomas"). What good are these "monoclonal antibodies"? Not much on their own. However, they can be further modified for various special tasks . . .

Monoclonal Antibody Applications

Diagnosis: Vat-grown monoclonal antibodies can have fluorescent or radioactive molecules bonded to them when they are created. When added to blood, they will find the specific protein, virus, et cetera, that they are designed to target, and bond with it. A blood sample can then be taken and a filtration process used to wash away any antibodies that aren't attached to something. If any light or radiation is still emitted after the wash, it means that the antibodies have found whatever they were sent to find. This process is being used today, and promises rapid but accurate medical diagnosis. At TL8+, wide-spectrum tests using monoclonal antibodies are standard in clinics, diagnostic beds, automeds and hospitals.

Continued on next page . . .

Monoclonal Antibodies (TL7) (Continued)

Target-Seeking Drugs: Treatments such as chemotherapy release toxic chemicals, intended to kill cancers, into the body. Unfortunately, they also poison the body, and selecting a dosage that will kill cancer but not the host is very difficult. By bonding drugs to monoclonal antibodies, far more toxic chemical scan be used in much smaller amounts, because the antibodies deliver the chemical directly to the target cells. This is like the difference between "carpet bombing" and a "smart" bomb: the first may kill a lot of innocent victims without doing the job, while the second takes out the target with minimal collateral damage. Aside from smart-bombing cancers, monoclonal antibodies can be used as the targeting system for other drugs, guiding various chemicals directly toward specific proteins. Many of the "wonder drugs" described in ***GURPS Cyberpunk, Space*** and ***Ultra-Tech*** use monoclonal antibodies.

Other Uses: Vat-grown monoclonal antibodies essentially permit the biochemical equivalent of finding a needle in a haystack. This makes them useful for a wide variety of industrial and medical processes, such as refining exotic proteins, creating "diagnostic bed" sensor systems, and consumer products, such as . . .

Continued on next page . . .

Surrogate Motherhood (TL7)

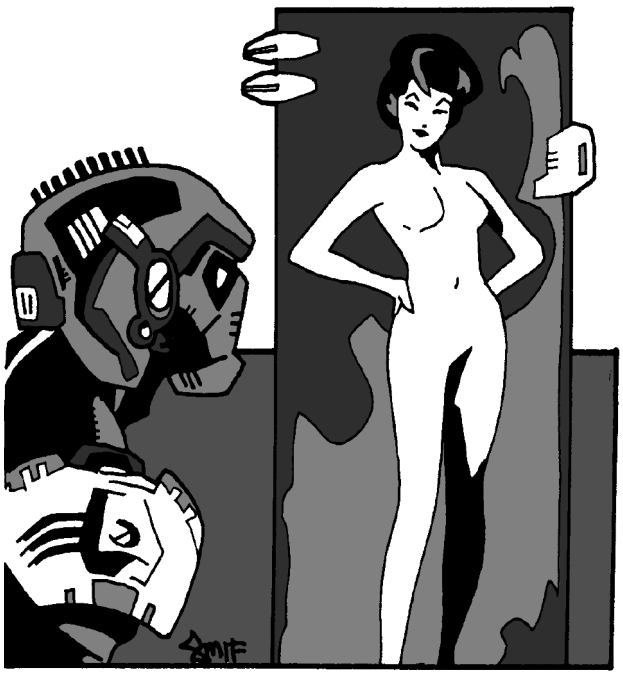
A fertilized egg or early embryo can be transferred to a human host mother to grow to term within her. This has the advantage of not requiring a bulky, ultra-tech growth tank (see below). Some people believe it might also be better for the mental or physical health of the child. The disadvantage is that surrogate motherhood, especially for pay, is often considered unethical and illegal, and hence can be expensive.

In areas where the practice is legal, a host mother can be hired for about $20,000 plus payment of medical bills. Usually, a potential mother has to undergo a medical exam to certify she is healthy, and sign a contract agreeing to refrain from certain activities (e.g., substance abuse, dangerous sports) that might put the developing child at risk. In some areas, professional associations of surrogates may exist.

If surrogate motherhood is illegal, the fee could be much higher. Cheaper host mothers could be hired in impoverished regions, such as slums or Third World nations. However, many employers might balk at this, partly due to fears that a desperate and impoverished mother might be more likely to suffer from ill health or substance abuse, and partly due to genetic snobbery.

There is some chance that the mother will become attached to the child and try to keep it, or change her mind and decide to terminate the pregnancy. This risk is increased where surrogate motherhood is considered illegal, since there is little the employer can do in such circumstances without admitting guilt. In any such disputed circumstance, the exact legal status of surrogate motherhood, and the nature of the transaction involved, will usually influence the decisions of the court in determining whether the rights of the host mother, the employer or the developing fetus take precedence.

Assume that a pregnancy at TL7+ goes as planned if the mother successfully makes a (HT+TL) roll. If the mother's roll fails, roll against the Physician skill of the attending health care provider, at -5 if the mother had a critical failure. If this roll succeeds, the baby and mother are fine, although the baby may be born late or premature. If this roll fails, *separate* Surgery rolls should be made to save baby's and mother's life. Use the normal Surgery rules (p. B56), with a -5 modifier if the Physician roll was a critical failure. Failure on the baby's roll will kill it; failure on the mother's roll does 2d damage to her (4d damage on a critical failure), and may cause sterility (see p. CI84) if she fails a HT roll. The surgical team can opt to put either mother or baby at greater risk in order to save the other; if so, add a bonus of up to +3 to the Surgery roll of the favored patient in exchange for a matching *penalty* to the other's Surgery roll.



If the mother is carrying a genetically-modified baby that is of unusually large size or has a partially non-human biochemistry (especially the Unusual Biochemistry disadvantage, p. CI106), a penalty of -1 to -8 can be applied to HT and Physician rolls.

If the mother was exposed to a mutagenic source (radiation, chemicals, et cetera), addictive drugs or excessive amounts of alcohol during her pregnancy, roll vs. her HT. A failure means that the baby suffers from a -1 or -2 to ST, IQ or HT, an Addiction, or other physical or mental disadvantages (GM's option). Critical failure means that it suffers these problems *and* is born Terminally Ill (p. CI84). Success means it survived and is healthy. Critical success *might* mean a favorable mutation, if the GM wishes.

Adventure Seed – Rosemary's Bioroid: A surrogate mother is expecting a baby. A few weeks before giving birth, she changes her mind and decides to keep the child, fleeing to a region where surrogate motherhood is illegal. What she doesn't know is that she's carrying a combat bioroid instead of a human infant – part of a corporate (or even criminal) "black program."

Growth Tank (TL8)

Sometimes called an "artificial womb," the growth tank is a basic tool of ultra-tech engineering. Programs to develop artificial wombs are

underway in the 1990s; they should be available in the early 21st century. The main impetus driving this technology is not so much the desire to do away with the womb as the need to create incubators that will enable very premature babies to survive. Currently, babies born less than six months after conception have little chance of survival, because their lungs aren't ready to breathe air. Artificial wombs that use oxygenated fluids such as perfluorocarbons can enable much younger infants to survive, and may lead to actual growth tanks in early- to mid-TL8.

An artificial womb contains the necessary facilities for growing a multicellular animal (like a human) from gametes to healthy adulthood without their leaving the tank, eliminating the need for surrogate mothers. Growth tanks may be used to grow clones, genetic constructs or unmodified human embryos. This is no faster than natural growth – growing a human from germ cells to a baby would require about nine months; growing them to adulthood would require 18 years.

Growth tanks may be enclosed, but are often transparent so that observers can see the developing organism. They are big enough to allow the organism within to grow to adulthood.

An organism developing in a growth tank has the same degree of awareness as a baby in its womb. Individuals kept in the tank past the fetal stage and into childhood will be conscious, but will not develop mentally in the absence of stimuli. Electrodes attached to muscle groups can keep them stimulated in the tank, the body twitching constantly in an unconscious exercise program that maintains muscle tone.

It is safe to remove a creature from the tank before its intended "birth" date, provided it has developed past the fetal stage. If the organism has been in there for less time, it will not be able to survive outside the tank without medical care (and prompt transfer to another growth tank or surrogate mother).

Destroying a growth tank (e.g., smashing it) and severing the artificial umbilical cords will free the organism. This will kill it if it has not developed enough to be born, but is probably not significantly more traumatic than a normal birth otherwise.

A growth tank designed for a human-sized organism is 250 lbs., 50 cf and $200,000. It runs on building or vehicle power (0.1 kW). Cost (only) is halved at TL9 and again at TL10. At TL12, advances in biotechnology allow the creation of much smaller and cheaper *portable growth tanks* that are only 100 lbs., 20 cf and $5,000. These can run for a year on a D cell. All growth tanks require a Complexity 4+ computer to monitor life support.

Normal growth tanks can be used to grow any single organism of up to human size (two hexes when standing). For larger growth tanks (e.g., for horses or dinosaurs), multiply the weight, volume, cost and power requirement by the size in hexes an adult will occupy.

Forced-Growth Tank (Late TL8)

Also known as a "zoom womb," this is a growth tank equipped to tremendously accelerate the development of the organism within it without doing it any harm.

At present, forced-growth tanks are very much science fiction; no one knows how to make them. However, without forced-growth tanks, many of the dramatic possibilities of cloning are rendered moot due to the time it takes a human being to develop to adulthood. With a forced-growth tank, it is possible to take a cell sample from someone, make a clone and force-grow it to maturity, or even the same age as the cell donor, effectively allowing the creation of clone doubles. It's also possible to mass produce armies of cloned or genetically-altered people.

A forced-growth tank is identical to a growth tank, with the exception that the organism within it develops much more rapidly. A forced-growth tank takes a minimum of three weeks to mature a human from a cell into a baby that can survive outside the womb. If not removed from the tank, the growth can then be accelerated to the even more rapid pace of just over one physiological year per day until the organism reaches age 25.

The force-growth process can be deactivated, allowing the person to grow in a normal fashion, exactly as within a growth tank. Once it is stopped, it cannot be restarted without killing the organism. Alternatively, the organism can be "stabilized"

Monoclonal Antibodies (TL7) (Continued)

Disposable Test Kit (TL8)

A cigarette-sized plastic vial. The user pricks his finger on the included needle, lets a drop of blood fall in, shakes and squeezes to break the membrane. If the vial glows a particular color, he tests positive. No skill is required to use it, but each kit tests for one *specific* thing. Kits are available that test for various common and not-so-common diseases, from AIDS and other sexually transmitted diseases, to various types of influenza, to cancer. Others can be designed to detect pregnancy, malnutrition or the use of a specific drugs. Military-issue kits may test for various biochemical weapons. A genetics lab is needed to design new test kits – and of course, kits will only be available for testing *known* diseases, drugs, et cetera. 2 oz., $5. LC 6. Civilian test kits may be available from vending machines.

At TL9+, monoclonal antibodies are supplemented by tailored nanomachines that perform similar tasks with even more precision.

In Vitro Fertilization (TL7)

In vitro ("in glass") fertilization allows pregnancy without sex. A female's eggs are fertilized with sperm in a laboratory dish, and the resulting embryo is implanted into her uterus, into that of a surrogate mother or – at TL8+ – into an artificial womb such as a growth tank or forced-growth tank.

Today, *in vitro* fertilization (IVF) is a relatively common but somewhat tricky and expensive procedure. In humans, each attempt costs about $5,000 at TL7. Divide the cost by 5 at TL8, and by 10 at TL9+. There is only about a 1-in-6 chance of success per attempt at TL7 (each attempt takes at least 4d weeks); at TL8+, this chance increases to 5-in-6.

One advantage of IVF is that it makes it possible to perform very early genetic testing. If genetic problems are suspected (e.g., the mother or father was exposed to mutagenic chemicals or had a history of genetic defects), IVF may be preferable for this reason alone.

Deep Learning (TL9)

This future (TL9+) technology is often used in conjunction with forced-growth tanks. Deep learning is an intensive process that works on a "blank" brain (one with no prior experiences outside an artificial womb), making extensive use of technologies such as sleep-teaching tapes, learning-enhancing drugs, virtual-reality sessions and (at TL10+) neural-interface "dreamgames" to program someone with a synthetic set of skills and knowledge.

Six weeks of deep-learning "socialization" can give someone basic life skills. This can take place while a person is growing in a growth or fast-growth tank. Deep-learning socialization training gives the subject control over his own body and the ability to understand and speak one language at IQ level.

Up to an extra year and a half (more time imposes too severe a psychological stress) can be spent in deep learning. Every month allows two character points to be spent on skills. Thus, someone who came out of the tank after 18 months could spend 36 character points on skills, much like an 18-year-old human.

Continued on next page . . .

using an artificial hibernation process to keep it unconscious and at the desired physiological age for as long as it remains in the tank.

While someone is being force-grown, he is unconscious. A person newly awakened from a forced-growth tank is a blank slate, with no memories or skills.

A forced-growth tank designed for a human-sized organism is 250 lbs., 50 cf and $1,000,000. It runs on building or vehicle power (0.1 kW). Cost (only) halves at TL9 and again at TL10. At TL12, advances in biotechnology allow the creation of much smaller and cheaper *portable forced-growth tanks* that are only 100 lbs., 20 cf and $10,000. For larger tanks, multiply the weight, volume, cost and power requirement by the size in hexes an adult will occupy.

Note: Forced-growth tanks are referred to in most other ***GURPS*** books as "clone tanks." The tanks actually have nothing to do with cloning per se; they are simply the means by which a clone can be rapidly grown to a useful age.

Growth and Forced-Growth Tank Fees

An institution that provides growth tank services will usually charge the following fees to its customers:

• $1,000/month to grow an embryo in a growth tank (or a forced-growth tank *without* using forced-growth). Growing a human embryo to a baby would thus cost $9,000 and take the usual nine months, while leaving him in the growth tank and growing him to age 25 would cost a further $300,000 and take 25 years.

• $1,500/week, for six weeks, to force-grow a human to maturity (or to any earlier stage of development).

For species that mature earlier or later, modify the times and costs appropriately. For larger-than-human organisms, multiply the cost by the size in hexes. However, the only places likely to be set up for growing large organisms are major biotech corporations. Persuading them to tie up their facilities requires either a very large advance order, inside connections or a substantial additional fee of perhaps 10 times the cost.

Chronowomb (TL15)

A chronowomb is similar to a forced-growth tank, except that instead of using chemicals to accelerate growth, it creates a miniaturized pocket of accelerated time within the tank. Typical chronowombs produce about 700:1 time dilation – about a day of growth every 2 minutes, a month every hour, or 2 years every day.

External controls allow the chronowomb to be set to operate for a specific amount of time. When not being used in chrono-acceleration mode, it functions as an ordinary growth tank.

Unlike forced-growth, developed individuals (or even adult humans) can use chronowombs – but they should be careful with the setting or they may end up aging to death! A side effect of the time-acceleration process is disorientation followed by unconsciousness: individuals can't climb into a chronowomb and study skills or the like, although they can use it to heal (regenerating about 1 hit per 2 minutes).

A chronowomb built for a human-sized occupant is 500 lbs., 100 cf and $1,000,000; halve weight and volume, and divide cost by ten, at TL16. A chronowomb requires at least 10,000 kW of power and usually runs off building or vehicle power. For larger tanks, multiply the weight, volume, cost and power requirement by the size in hexes an adult will occupy.

Optionally, chronowombs may appear before TL15, if lower-TL time-manipulation or time-travel technology also exists. Fees for using a chronowomb are typically $1,000 per hour of "real time." For larger-than-human organisms, multiply the cost by the size in hexes.

Biotech Facilities

Gengineering isn't something that can be done on the kitchen table – specialized equipment is necessary.

Lab Facilities

These are necessary to fulfill the basic equipment requirements for genetic engineering tasks. Weight and cost are not reduced at higher TLs – instead, sophistication increases. Modifiers are given for both minor and major tasks. "Minor" tasks are things like genetic testing, or synthesizing a known protein. "Major" tasks include cloning, chromosome mapping and sequencing, genetic reconstruction and genetic engineering.

Full Genetics Lab (TL7)

This lab contains sufficient equipment and work space for one researcher and up to four assistants to perform advanced bioengineering. It contains tables, lab counters and refrigerators, as well as high-tech (and fragile) gear such as genetic sequencers, several PCR machines, incubators, culture vats, microscopes and other imaging systems. It gives +2 to skill for minor tasks, but no bonus if used for complex genetic engineering research projects that *need* a state-of-the-art lab. A big lab complex will contain multiple labs, allowing several research teams to do work at the same time. 20,000 lbs., 1,000 cf, $1,000,000, LC 5. Requires 3 kW power.

Standard Genetics Lab (TL7)

Found at small biotech companies or average universities, this is a less costly and more compact version of the full lab (above). It gives +1 to skill for minor tasks, but there is a -2 penalty on major projects. 4,000 lbs., 200 cubic feet, $200,000, LC 5. Requires 1 kW power.

Small Genetics Lab (TL7)

A work table or counter, fridge and *basic* genetic-engineering equipment. This is typical of community colleges, reclusive geniuses and amateur bio-terrorists. It gives no bonus to skill for minor tasks, and a -5 penalty when working on major projects. 500 lbs., 100 cf, $50,000, LC 6. Requires 0.5 kW power.

Suitcase Genetics Lab (TL8)

A miniaturized, man-portable genetics lab. It gives -2 to skill for minor tasks, and a -8 penalty when working on major projects. It takes 10 minutes to pack or unpack. 20 lbs., 4 cf, $12,000, LC 5. Requires 0.1 kW power.

Lab Biohazard Precautions

Biotech labs are rated for the level of *biohazard safety* that is practiced in them:

P1 – Ordinary microbiological lab procedures, such as using absorbent mats to catch spills and ultraviolet lamps to kill contaminants, and wearing protective gloves.

P2 – As above, but restricting access (i.e., a lock and a "Keep Out" sign). This is the highest level possible for a suitcase lab or hellkitchen (sidebar, p. 22).

P3 – As above, but lab air pressure is lower than its surroundings, so that airborne microorganisms blow in rather than out. Triple the size, weight and cost of the lab facility. Any critical failure that would result in the escape of biohazardous material should be confirmed by a second failure; if this second roll succeeds, the accident merely contaminates the lab itself.

P4 – Sealed lab. Lab workers change clothes and shower, and there will be an air lock between the lab and the outside world. May have security guards. Multiply size, weight and cost by 10. A critical failure that would result in the accidental escape of biohazardous material should be confirmed by a second *critical* failure (e.g., something else went wrong, like the airlock door malfunctioned). Deliberate sabotage can still circumvent these precautions!

Deep Learning (TL9) (Continued)

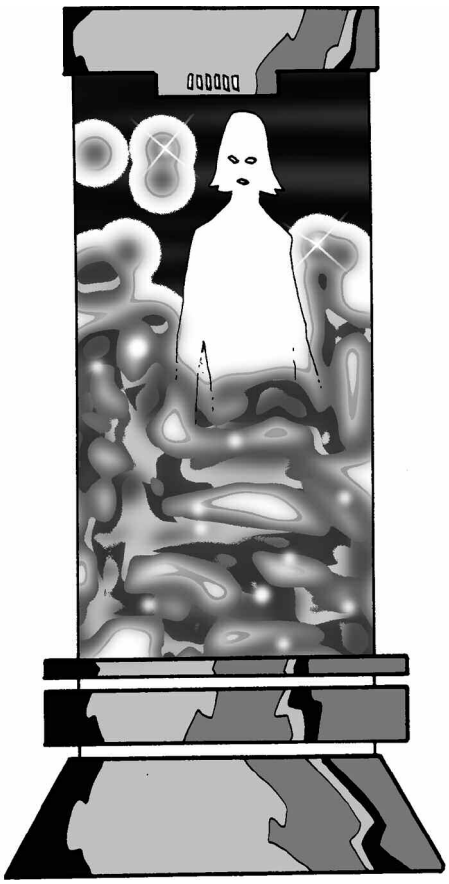
Deep learning is just over 50% actual study and simulated practice, the remainder being simulated sleep, dream, rest or play. Thus, someone undergoing it is actually spending about 12-13 hours a day studying, or some 400 hours a month. Deep-learning can also "program" a mental disadvantage into someone, with -1 point worth every month possible *instead* of skill training. This sort of programming is not entirely reliable, and in a small minority of cases (GM's option, anywhere from one in ten to one in a million) may fail to "take."

A deep-learning system requires a Complexity 6+ computer and specialized teaching programs (about $100,000 for life skills, $12,000 per skill to be taught for other programs) that control the various virtual-reality simulations, drug doses, et cetera. Peripheral hardware must also be added to the growth or forced-growth tank. This costs about $100,000 at TL9 or $10,000 at TL10 (due to use of neural-interface technology), with the cost being halved at TL11 and again at TL12. The fee charged for the deep-learning process itself costs $5,000 per character point or point of disadvantage gained at TL9, halved at TL10 and again at TL11+.

Hellkitchen (TL8)

This is a suitcase genetics lab (p. 21) optimized for producing biological weapons. It contains the necessary precision scientific equipment (including a miniaturized gene-splicing and PCR machine), cell cultures and genetic engineering computer software to transform an ordinary kitchen into a biowarfare laboratory. A hellkitchen gives -2 to skill on minor tasks, and a -8 penalty when working on major projects – with the exception of disease cultures and similar bio-weapons, where the penalty is only -5. It can also manufacture additional doses of a germ from an existing or modified culture at a rate of one dose per hour; an unmodified skill roll should be required to set this up.

The hellkitchen is so compact because it lacks even rudimentary safety features; any critical failure results in some form of disaster (e.g., the user becoming infected or releasing a plague). This applies whether trying to modify a disease or find a cure for one. In its suitcase-sized package, the hellkitchen weighs 20 pounds and costs $50,000. Packing or unpacking it takes 10 minutes.



Lifebanks and Genome Libraries (TL7)

A *lifebank* is an indexed collection of seeds, eggs or embryos. A well-stocked lifebank will have examples of many different genotypes within a particular species, to ensure genetic diversity. About 50 individuals per species would be the minimum breeding populace needed to allow that species to be reintroduced successfully, while 1,000 could preserve most of a species' genetic diversity.

The simplest stable ecosystems (e.g., an isolated lake) might have under 1,000 species, but most have 10,000 or so. Earth may have as many as 80 million species – 2-4% of all the species it has ever had. Extensive lifebanks may be established as a safeguard against extinction. At higher TLs, they can be found aboard colonizing "seedships." Lifebanks require $500, 5 lbs. and 0.1 cf per embryo stored. A live bacterial culture, or large quantities of germ cells (hundreds of human gametes, plant seeds or bacterial spores), can be frozen for the same amount of weight, space and money.

A *genome library* stores the data for a mapped and sequenced genome in digital form. This information can then be used to synthesize DNA, although growing a complex organism like a human with nothing but a digital genetic code requires TL10+ technology and is far more time consuming than if actual samples existed. (See *Genetic Reconstruction,* p. 11). A complete genome database (plus Complexity 2 indexing programs) for a particular species genome is $5,000 (and 5 gigs) for microorganisms or plants and $20,000 (and 20 gigs) for other life forms.

Other Biomedical Facilities

Containment Tubes (TL8)

These resemble giant, vertical test tubes, large enough for a person to stand upright in, resting atop a base platform containing a life-support system and powerful vacuum pumps. They are used for containing human-sized specimens. In a ***GURPS Supers*** campaign, any *real* mad scientist's lab will have a few of these for holding captured superheroes or experimental specimens.

The tubes are sealed, but are connected to an external air conditioner that recycles the air within them. They can also be pumped empty of air in 30 seconds. Canisters may be attached to the tubes to allow gases or liquids to be pumped into them (e.g., sleep gas, nerve gas, germs or proteus virus), or to maintain a different atmosphere within the containment tube. A gas canister suitable for flooding the tube (requires five doses of whatever gas or other agent is used) is 5 lbs. and $300. It can hold 100 doses of gas.

Access to the tube is provided by a transparent sliding door, which causes part of the tube to slide open. The door's lock cannot be picked from inside the tube. Opening or closing the door, or controlling life support in the tube, is accomplished using either controls on the base or an external computer terminal. The containment tube itself is made of a plexiglass-like material with DR 30 and 20 hit points. Add 10 to DR per TL over TL8.

Each containment tube is $6,000, 300 lbs. and 15 cf. It runs off building power (0.1 kW). For double cost, the containment tube can have twice the DR; at four times cost, three times the DR. Containment tubes for beings larger than humans are possible; multiply cost, weight, volume and power requirement by relative hex size. Growth tanks, forced-growth tanks and chronowombs may be outfitted as containment tubes; add half the weight, cost and volume of the tube to the weight, cost and volume of the growth tank or womb. This is useful if growing dangerous beings.

Cryocase (TL8)

This is a portable cryogenic storage case, normally used for transporting organs, frozen embryos or similar fragile biological cargoes. Its interior can be configured to contain a human head or arm, up to three large organs (heart, kidney, et cetera), or twice that many smaller organs (eyes, for instance). It will preserve them for as long as it has power, after which they will spoil within 1d hours. The cryocase is also suit-

able for transporting other products that need to be frozen – evidence samples or certain drugs, for instance. The case is about the size of a large suitcase. When empty, it weighs 10 lbs. It costs $2,000. A single C cell powers it for 24 hours, or it can be hooked up to building power (negligible requirements) to run indefinitely.

Portable Brain Pod (TL8)

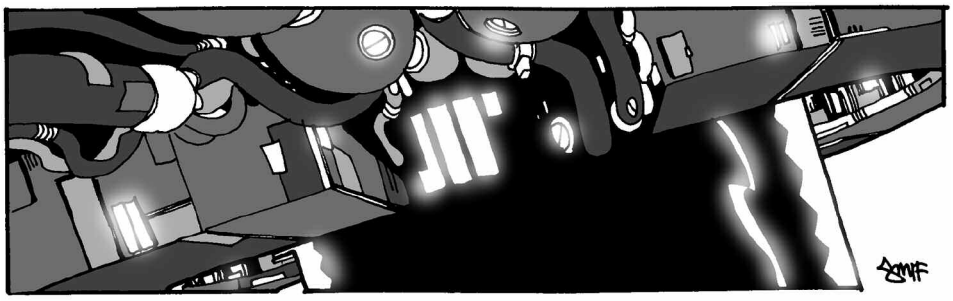
This is a portable suspended animation unit that is specifically designed to keep a disembodied brain (and portion of the spinal cord) alive. It is used for the transportation of disembodied brains, generally prior to a brain transplant or total cyborgizing operation. It can also be used for long-term storage.

A portable brain pod does *not* include the systems needed to keep the brain conscious, or any neural connections that would allow the brain to operate equipment such as neural interfaces, communicators or sensors. (In fact, it includes systems designed to keep the brain unconscious, as a conscious brain would suffer total sensory deprivation, which could damage its sanity.) This is very deliberate, as it allows the brain to be quickly and relatively cheaply installed or removed from the pod without the extensive and very expensive surgery required to make such connections. This is why placing a brain in a portable brain pod is much cheaper than transplanting it into a human body (p. 66) or cyborg body (p. RO52 and p. UT106), or keeping it conscious in a permanently disembodied state (p. P98).

A portable brain pod is 80 lbs. and $40,000, including a D cell power supply (good for up to a month; a spare socket allows one cell to be removed while another is still operating) and a casing. Weight and cost are halved at TL9 and again at TL10. It uses negligible amounts of vehicle or building power.

Safely transferring a brain from a living body to a brain pod requires a well-equipped TL8+ hospital, TL9+ automed or TL13+ chrysalis machine. Most hospitals will charge about $10,000 at TL8 for this service. The operation takes six hours to perform. If a character wants to try it, it requires a successful Surgery-5 roll, with failure resulting in a transplant to the pod but brain damage of some sort – such as a permanent loss of 1d points of IQ – and critical failure resulting in death.

Transplanting a brain from a brain pod into a full cyborg body (p. UT106), total cyborg body (p. RO52) or organic body has its normal cost. However, it takes only 80% as long, and any skill rolls the GM requires to perform the operation are +2, since part of the work is already complete.



Portable Microsurgery (TL8)

This is a compact microsurgical operating theatre, optimized for performing transplants and neurosurgery (see Chapter 3), as well as modifying, repairing, removing and installing bionics. It is small enough to fit in a room, trailer or van, and contains enough tools to allow two medics to work at the same time. It adds +3 to Surgery, Diagnosis, Electronics or Electronics Operation rolls related to microsurgical tasks.

This sort of setup is favored by splicers (p. 129) and organleggers (p. 129), since it can be packed up if the law comes calling. Security and intelligence agencies, and military units that use a lot of cybernetics, will also have a few of these installed in vehicles (or safe houses), both for treating their own agents and for operating on defectors or prisoners – removing or inserting implants.

The portable microsurgery weighs 500 pounds and costs $30,000. It requires about 25 cubic feet of space, or 10 cubic feet when packed for storage.

Chrysalis Machine (TL13)

The ultimate in biomedical technology, a *chrysalis machine* is a medical device designed for nanotechnological repair and transformation. It is a coffin-sized or larger machine that the user steps into or is placed within. The machine then spins a life-support web around the patient, completely enfolding him. Each cell is surrounded with microscopic biological repair and support machinery, which takes over control from the patient's own DNA. The chrysalis instructs the cells to begin self-repair procedures, and if necessary, takes the patient apart cell by cell and rebuilds him in accordance with its own programming.

A chrysalis can heal almost any wound. Normal HT loss is restored at 1 HT per hour. Crippled body parts or missing fingers or toes are regenerated in 24 hours; missing organs or limbs regrow within a week. This is slower than a regeneration field (p. UT104), but much safer! On a successful Physician-2 roll, the time can be halved (12 hours, or three days for a missing limb); failure means it takes the normal time, critical failure may have perilous side effects.

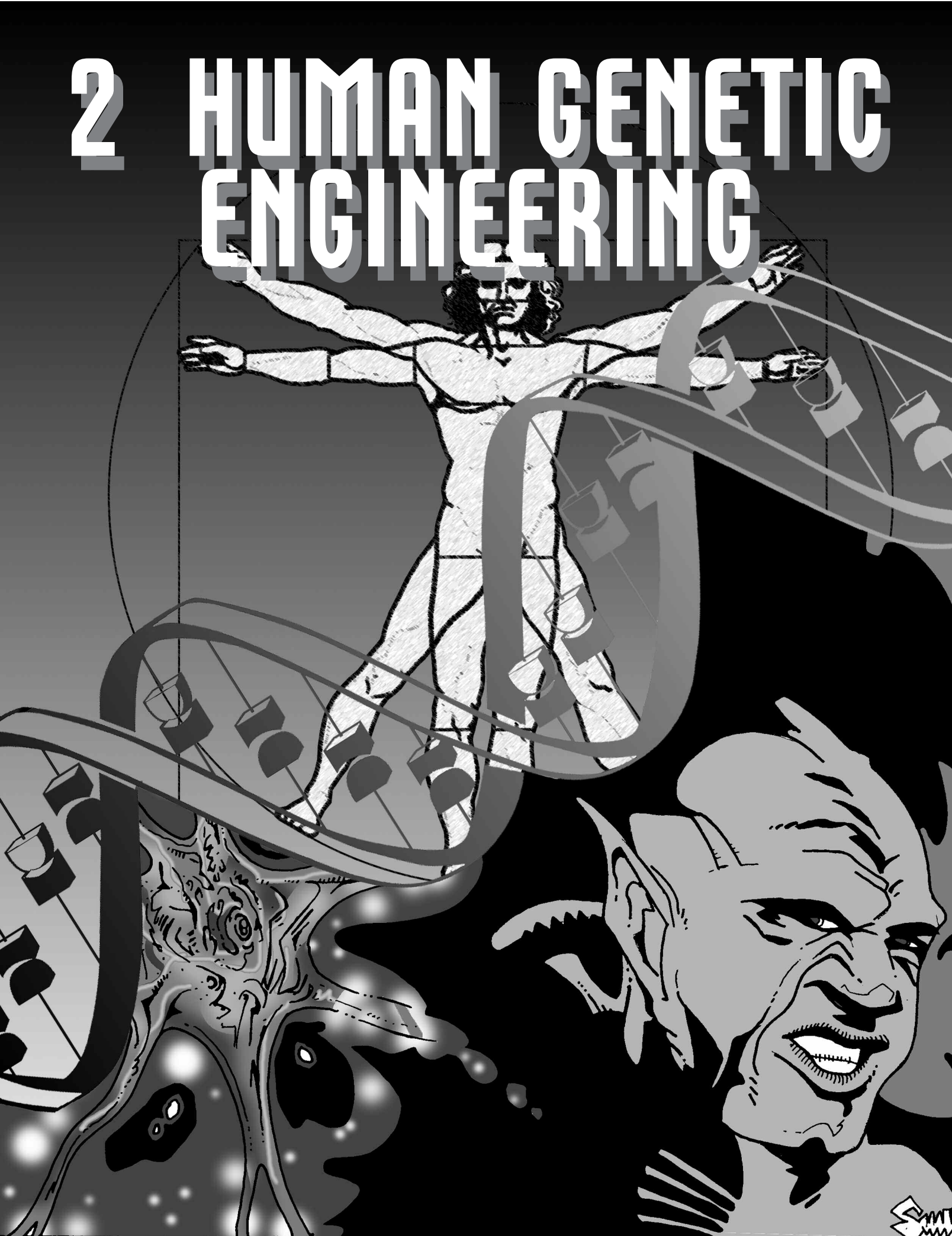
A person who is dead, but who has not suffered serious brain injury, can be restored to life. Roll against Physician, at -2 for every hour the subject has been dead. Success restores the patient to life; failure by 1 or 2 indicates recovery, with personality intact but substantial memory loss (equivalent to Partial Amnesia, p. CI86). Failure by 3+ also restores him to life, but as a blank-minded clone, with no memory or personality. A person who has suffered severe brain damage can still be restored, but only as a blank-minded clone.

Beyond that threshold, if there are some cells left, the chrysalis can clone the original (the body may be totally crushed or burned, but not disintegrated). The chrysalis machine functions exactly like a forced-growth tank (p. 19). The result will be a blank-minded clone, unless a brain-tape is available.

A chrysalis machine can also be used to transform someone, performing safe, fast clinical metamorphosis (see p. 79) in conjunction with a metamorphosis nanovirus.

A chrysalis machine costs $150,000 and weighs 1,100 pounds. It takes up 75 cf and uses 0.1 kW of power.

2 HUMAN GENETIC ENGINEERING



"What a piece of work is a man! how noble in reason! how infinite in faculty! in form and moving how express and admirable! in action how like an angel! in apprehension how like a god! the beauty of the world! the paragon of animals! And yet, to me, what is this quintessence of dust?"

– *Hamlet,* William Shakespeare

Everyone thinks that they're the end product of evolution – *T. rex* probably thought that way just before he saw the comet flash. But with genetic engineering, we can take control of our own cells, making our children brighter, faster and immune to hangovers. We can even redesign people to live in space, so the next time some big rock hits, some of us won't be here.

Gengineering at Conception

A genetic engineer can insert recombinant DNA or RNA into a newly-fertilized human egg cell (a *zygote*) to alter its genes. Those genes will express themselves by producing somewhat different proteins. As the zygote develops into an embryo and then a fetus, the new proteins will make up different cells, and a child will be born with traits it would not have possessed had it remained unmodified. These changes will be passed on to its descendants. This process is known as "gengineering at conception," or more technically, *germline genetic engineering.*

Eugenic Germline Gengineering (TL8)

"We'd like our Katiana to be petite and beautiful, with big, violet eyes and jet-black hair. Could she have a tendency toward musical aptitude, with long fingers for playing the piano? We also want her to be good at sports – an athletic body type would be nice, so she could be a gymnast. Oh, and we want the standard features, of course: boosted immune system and genefixed heredity.

"Now, how much will all that cost?"

– Mr. and Mrs. Arlington

"Ever since my teens, I've really wished my parents had designed me for something practical. At least I don't get sick."

– Katiana Arlington III

This is what most people think of when they hear the term "human genetic engineering." This is the process of selecting gene *combinations* that ensure the appearance of traits the gengineer considers desirable; for example, good looks, high intelligence or perfect vision.

The abilities and disabilities of each of us result from traits inherited from a mixture of our parents' genes, modified by environmental factors such as diet, experience and education. Eugenic gengineering ("eugeneering") involves determining what genetic combinations favor certain traits, then using gengineering at conception to make it likely they appear. It does not add anything new to the human *genome,* so a eugeneered person will still appear perfectly human to genetic tests or scanners.

The major stumbling block in the road to eugenic modification is that desirable traits can result from the interaction of hundreds of different genes. Moreover, one gene may be involved in multiple traits – change it to produce one effect and there may be unintended consequences for the others.

The capability to perform eugeneering rests on possessing a complete map of the human genome (see *The Human Genome Project,* p.14) and a detailed understanding of how specific gene sequences affect human development. Completing a racial genome map is a TL8 achievement, and the ability to use this knowledge to perform complex eugenic selection is TL8+.

Efforts to determine the effects of specific, modified gene sequences often proceed by tinkering with the DNA of individual genes one at time, using animal subjects. Since mammals such as mice share much of our DNA and produce successive generations in a short period of time, animal testing can provide considerable

Defining "Human"

What *is* "human"? This is a philosophical question, but it may also be an important legal and social one in many campaign settings. Definitions could be based on the amount of human vs. non-human DNA (i.e., "eugenic vs. species modification"). Other common criteria include:

Anatomy: Certain standards may be set, such as being physically indistinguishable from a normal human or, perhaps more loosely, having a generally humanoid appearance.

Birth: This might exclude "non-borns" who came out of incubators or clone tanks, as opposed to "test-tube babies," conceived artificially but gestated inside a surrogate mother.

Intelligence: A racial IQ modifier of -3 or worse might disqualify someone as legally human.

Theology: Belief systems may have their own criteria, related to things like the presence or absence of a soul, or whether the person fits a definition of man in a religious text.

Sex Selection

"Of ***course*** *a boy! We must have a male, so he can marry and inherit the family business."*

"You want a boy, she wants a boy . . . If every parent is going to have boys, who are they going to marry?"

This is chromosome manipulation rather than gene manipulation. Sex selection is simply a matter of choosing whether the baby will have XY (male) or XX (female) sex chromosomes. (If anyone wanted, such tinkering could also result in a natural hermaphrodite.)

Sex selection is easy, as genetic engineering goes, but may have profound effects on society. For example, if parents favor boys over girls (as in many Earth cultures), the result could be a demographic disaster within a generation, especially if population controls restrict families to one child each.

At TL8, sex selection costs $1,000 if it's the only genetic modification ordered; it's free with more extensive gengineering. Halve the price at TL9 and again at TL10+.

See also *Cross-Sex Clones,* p. 16.

Sex and Genetic Engineering

"I have my first Daddy's hazel eyes and my second Daddy's red hair, but they bought my sense of direction from the gene bank."

– Chance Mackintosh

At TL9, same-sex partners can use genetic engineering to blend their genetic material together. Women don't need to involve men at all; men will still need a female egg donor, although the genetic material from the egg nucleus could be removed and replaced with genetic material drawn from the male partners. Splicing genetic material from same-sex partners together costs an extra $10,000 and takes about a week. Halve this at TL10 and again at TL11+.

Linked Advantages and Disadvantages

Sometimes, the genes that combine to produce a specific desirable trait are mingled with those of other traits. GMs can rule that this is the way it works for specific advantages, requiring them to be combined with disadvantages, distinctive features or even other advantages. This has considerable basis in reality, and is very common in science fiction – what if an exotic advantage (like Intuitive Mathematician or a psi power) were linked to a disadvantage like Albinism or Short Lifespan?

Sex-linked traits are also possible – in the case of a variant race, this means that males and females will have slightly different racial templates.

insight into the effects on humans, especially if the test animals are gengineered to possess additional human genes. As more data is gathered on each gene's role in human development, computer simulations may supplement or replace experimentation, making eugenic selection far more practical, and allowing a designer to work with a standard "tool kit" of genes known to produce certain effects.

Once this capability is achieved, eugeneering can create "designer people" whose potentials are enhanced or skewed toward a specific physical or mental ideal. Changes may range from the obvious (good looks, muscular build, 20/20 vision or "double-jointedness") to the subtle (higher IQ, gengineering of the adrenal glands to give someone a positive stress response).

Germline Gengineering for Species Modification (TL9)

"Yesterday, the Mokoto twins started laughing and teasing me 'bout my genemods again, calling me Girl Dracula and stuff. I bit one of them, but she beat me up – ain't no room to fly in the ship; it's hard to fight back proper when your bones aren't strong as theirs. I can't wait for planetfall on Darktree. Soon we parahuman kids be gliding from tree to tree, while them crew-brats be stumbling around in the groundfogs in their chillsuits and respirators. Then we see who's laughing."

– Tizbeth Sung-Morton (age 9), Darktree Colonization Fleet

Species modification involves gengineering for complex traits that never existed within the human genome, such as gene sequences that produce modifications to human anatomy. Some changes may be internal, like a modified liver that's better able to filter toxins. Others might be obvious, like a coat of fur or a pair of functional extra arms. Again, the main difficulties lie in predicting how the effects of a specific genetic change will cascade over the entire genome, and in making major changes in hundreds or thousands of genes at once. The tools to do this become available at TL9 – megacomputers for running extremely complex genetic simulations, and bio-nanotech, such as highly-sophisticated, tailored retroviruses or nanoviruses.

Gengineers might synthesize genes for totally new abilities,but it may be easier to enhance existing human traits, or design non-human abilities by basing them on the genes of terrestrial animals. This can be background information ("I'm part bat?") or imply colorful physical features (someone whose bat DNA sequences give them sonar and wings may have other chiropteran features, such as fangs and pointed ears). These may be the unintended results of cross-linked genes, or necessary for a given trait (e.g., pointed ears for ultrasonic hearing).

This sort of transgenic gengineering is already in the experimental stage at TL7, with single human genes having been inserted into "pharm animals" (see p. 98) so that their metabolisms produce necessary proteins. Once the human genome and several nonhuman genomes are mapped and sequenced, complex human transgengineering could become a reality, limited mainly by ethical considerations.

Adding traits from very different species – like insects, plants or aliens – probably requires high technology (TL11+), unless the genetic sequences are extremely simple. The guidelines under *Designing Variant Human Templates* (p. 29) suggest TLs at which various advantages and disadvantages can be produced by gengineering.

Chimerization

Technically, a *chimera* is an entity created when the cells of two dissimilar *blastocysts* (very early embryos) are carefully fused together so that they form a single organism. If the blastocysts are from different species, the result – if it survives – will be a new creature with traits of both.

While a "classic" chimera is not too difficult to achieve with bacteria, plants or very closely related animals (e.g., between dog and wolf blastocysts), the likelihood of a viable chimera declines as the species become more diverse. To produce more exotic chimeras, such as human/wolf, the germ cells from each embryo must undergo genetic engineering to improve their compatibility. Additional cell grafts or microsurgery are used to ensure the correct mix of cells and to correct any resulting deformities in the

developing embryo. Cross-species chimerization is unlikely to be easy. The path to success will be littered with failed fusions resulting in dead embryos and aborted, defective or monstrous fetuses. Even a successful chimera may have genetic flaws, or be born with hormonal imbalances that can cause psychological problems.

In game terms, there isn't that much difference between chimerization and germline gengineering, especially since the techniques are likely to blend together. As such, chimerization uses the germline gengineering rules – design the species as a gengineered animal or human, with appropriate cross-species characteristics. Since a chimera's fusion occurs on the cellular level rather than the genetic level, it is less of a "complete" organism. *All* chimera templates should have these disadvantages (as unintended defects): Delicate Metabolism (-20 or -40 points, p. CI81), Sterile (-3 points, p. CI84) and Unusual Biochemistry (-5 points, p. CI106). A lower HT is also reasonable.

Objectives of Human Gengineering

Once we have the technology to radically redesign a human, would we want to do it? Here are some reasons that might drive gengineers:

Pantropy

A term coined by writer James Blish (from Greek, "grow anywhere"), this is the practice of adapting humans to live and work in hostile or alien environments. People designed to survive without an artificial environment may be safer (due to reduced risk of accidents) and, in the long run, less expensive – things like atmosphere plants, artificial gravity, space suits or domed cities don't come cheap, and actual terraforming is a massive expense.

Moreover, if long-term colonization is planned, a colony is more likely to be *psychologically* stable if the colonists and their children can live on "their" world without the constant threat of death if some technological system fails. If there is a local or widespread breakdown of civilization, such as a war, blockade or "long night" (see p. S13), colonies of altered people are far more likely to survive the loss of their technological infrastructure.

Homo Superior

Gengineering may be driven by the desire to create "better" or "super" people. This is the major goal of eugeneering, but it can also be taken farther via species modification.

Typical goals include improved health, longer life (even immortality!), mental enhancements like improved intelligence or memory, and superior physical abilities such as enhanced strength or speed. Other objectives may be to gengineer away human dependencies, such as the need for sleep.

"Homo superior" may have generalized improvements in many areas, or be more specialized, gaining some abilities at the expense of others. Unmodified humans may react with fear or envy to a gengineered super-race, especially if they can't afford to give their children the same kinds of modifications.

On the other hand, extensive or limited gengineering of this sort may be applied to an entire society. For example, an effort to ensure everyone is gengineered with an enhanced immune system. The exact concept of a "superior" person may also be driven by ethical or ideological considerations. A utopian commune might consider their "Homo superior" to be a peaceful race, and choose to delete genes linked with aggression.

Eugeneering and Society

Widespread practice of human genetic engineering can easily have a profound effect on society.

If it is available to anyone who can afford it, eugeneering may be used by wealthy parents who want to have "better" children. The descendants of the elite would not only *think* they were superior, but would actually be so, genetically speaking. This could turn the gulf between rich and poor into a gaping chasm, or lead to a backlash if demagogues attempt to parlay resentment against the gene-enhanced into political power.

In a socialist or authoritarian regime, gengineering might be subsidized or even mandated by the government, perhaps as part of a massive eugenics project. A benign program may subsidize genefixing to eliminate "defective genes" such as hemophilia. A society could expand that into a full-scale eugenics program aimed at producing a homogenous population or developing specialized "genetic castes" for different roles (see *Specialization and Genetic Castes,* p. 28). Perhaps a limited number of "approved" genotypes would exist, from which parents must choose (or have chosen for them). Or maybe everyone (except the leaders) must use the same genotype; it would end racism, but it might make the population easier to predict and control.

In some science-fiction backgrounds, there is a conflict between more "natural" societies and those that utilize gengineering.

Even if only one generation is altered, this affects the overall gene pool, as their children will inherit their genetics. Societies concerned with genome preservation might allow gengineering but mandate sterilization, so that if a gene-altered person is to have children, they'd have to be artificially inseminated or cloned.

Human Eugenics: Breeding Programs

It's possible to produce desired changes in heredity through a conventional breeding program rather than genetic engineering. This can be done at any TL, although it's most effective when the laws of heredity are understood. It requires locating breeding stock with suitable traits, mating them and observing the offspring. The process is repeated with each generation, with new mates chosen to strengthen desirable traits or remove undesirable ones.

This is the process that's been used for thousands of years to breed plants and animals. As far as we know, no one's ever done it successfully with humans – although to a limited extent, the entire earth is an exercise in eugenics ("evolution in action"), since most people (or their parents) choose their mates with at least some eye toward suitability for children.

Of course, this brings up the main problem with human eugenics. As humans usually prefer to choose their own partners, some form of coercion or indoctrination is often required. Since the process will take many generations, a very stable organization must be founded which can oversee the program through many generations.

Eugenics programs are usually devoted to designing a master race with superior physical and mental traits, a super-being with exotic psi powers, or specialized humans for a biological caste system modeled on an insect hive. Often, they are managed by communistic governments, secret societies or religious orders. In the past, the Nazis made half-hearted efforts in the field of eugenic breeding programs. Had the Reich really lasted a thousand years, they might have been successful; fortunately, they had less than a generation.

But can you really breed a "better" race with eugenics? A major problem would be the danger of inbreeding, with an increased possibility of recessive metabolic diseases. In ***GURPS*** terms, this would manifest as problems such as Epilepsy, Hemophilia, Weak Immune System and various forms of insanity. This is a danger in keeping the genes within a small population without having genetic testing and gengineering to detect and counter such problems.

Continued on next page . . .

Slave Species

Gengineering may be used to create a more tractable proletariat, underclass or slave caste. Slave species are usually designed for jobs that humans find dangerous, boring or demeaning, such as work in hostile environments, soldiering, manual labor, domestic servitude or concubinage.

Gengineered slave species often possess highly specialized physical and mental modifications to make them more effective workers, or condition them to accept their role. For example, pleasure models may be grown with stunning looks and glandular modifications that keep them constantly "in heat," while a janissary warrior could be gengineered with enhanced speed, revised pain threshold and boosted aggressiveness. These changes can leave members of a slave species more effective than humans within a limited sphere, while circumscribing their free will. This might result in simultaneous feelings of inferiority and superiority with respect to normal humans. Gengineers sometimes try to create a slave species so perfectly adapted to its role that it can't conceive of freedom. Of course, they don't always succeed.

Slave species are sometimes deliberately gengineered to look physically distinctive. For example, all slave bioroids may have blue skin, or be gengineered human/animal hybrids. This might be done purely for cosmetic reasons, but it also makes it more difficult for people to see them as "human" and harder for them to escape. It's even possible that differences will accrue because the law states that having a certain percentage of nonhuman gene sequences makes someone legally an animal or living artifact (which can be owned) rather than a human being (who is a free citizen). Thus, gengineers may have to make a slave species less human in order for it to be considered a slave species.

A variant human species designed as a slave species may not always remain as one. For example, changes in circumstances or social attitudes, or an unforeseen mutation, might lead to emancipation or revolt. Of course, if the slave species has been specialized for a limited role, this may limit its ability to enjoy its new-found freedom . . .

Specialization and Genetic Castes

Gengineered people may be optimized for specialized tasks from birth, without ever having been intended as slaves. This may be the decision of parents ("I want my baby to be a scientist") or of a community.

Taken farther, this could lead to a caste-based communism similar to the one in Aldous Huxley's novel *Brave New World:* citizens designed from birth for specific jobs, a drone-like working class indistinguishable from a slave species. They might be managed by an upper class of unspecialized people (normal humans or a *Homo superior* race) to give orders and handle unforeseen emergencies.

Such a society may dispense with sexual reproduction and reproduce through growth tanks or cloning. Ordinary citizens may be gengineered to be non-aggressive workers; faced with war, a state might deliberately alter its birth programs to grow (or simply mass-clone) a crop of super-soldiers or super-agents.

Hidden Dangers – Overspecialization and Evolution

Evolution is limited by the past of the organism – it can only work with what it has to start with. If you eliminate a "useless" trait entirely from a population, then the only way for it to reappear is by having the gene re-evolve from scratch, which could take millennia – if it ever happens at all. This can be a *fatal* error if that gene turns out to be not so "useless" after all . . .

Moreover, what if a gengineered species encounters a virus that even their jacked-up immune systems can't resist? Since they lack genetic diversity, there will be very little chance of any individuals being immune and their descendants surviving to carry on the species, as might have been the case had the plague struck the "imperfect" masses of naturally-evolved humanity. A real-life example of this is the cheetah. Some time in the prehistoric past, this cat species suffered a genetic "bottleneck" in which a large amount of the breeding population died (for unknown reasons). Modern cheetahs are descendants of a very few individuals, and as a species, cheetahs are highly vulnerable to disease, and suffer many birth defects due to inbreeding.

Similarly, it's all well and good to transform everyone into a race of "beautiful" people by, say, deleting gene sequences for excess body fat. However, if a disaster (comet strike, nuclear winter or whatever) triggers the next ice age and causes the collapse of technological civilization, the fashion-model beautiful *Homo superior* will all starve or freeze to death in short order – and since the gene for obesity is now gone, there will be nothing to select for in future generations.

Designing Variant Human Templates

A gene-altered person belongs to a "sub-race" or "variant race" of humanity, even if he represents the first (or only!) member. A variant human racial template should be created using the *Racial Generation* rules in ***GURPS Compendium I*** (pp. CI173-180) and the guidelines in this section, and have its own attribute modifiers, advantages, disadvantages and features. Ideally, it should be designed around a specific theme, depending on the intent of the designer and the kinds of genetic material used.

The traits chosen should have a scientific – or at least pseudo-scientific – rationale (e.g., Combat Reflexes and Extra Fatigue could be justified by "built-in war drug glands and enhanced lungs"). Others may be based on "xenogenes" from other species (e.g., Night Vision derived from cat genes). A variant human racial template can have any attribute modifiers, advantages, disadvantages or features the GM feels could be logically produced through genetic engineering. This rules out traits that represent social position, relationships, training, experience, conscious choice, injury or mental trauma (e.g., Dependents, Honesty, Literacy, Military Rank, Trained by a Master or Wealth).

The GM can also rule that some traits are too abstract, weird or difficult to gengineer, such as Luck. Individual paranormal or occult traits like psionics, Magery or being a werewolf may or may not have a known genetic cause.

In science-fiction settings, the GM may want to limit the genetic engineering of more exotic abilities to higher tech levels. This is the approach that was taken in Chapter 4 of ***GURPS Robots*** (*Biological Androids,* p. RO74ff), where restricted lists of advantages and disadvantages were assigned TLs based on how difficult they might be to produce through gengineering. For GMs who prefer this approach, the rest of this chapter is devoted to discussing what genetic engineers might plausibly produce at various TLs, and how they might do it.

GMs should feel free to modify the TLs, effects and rationales suggested for various modifications – they are only intended as guidelines, not hard and fast rules. Not every advantage or disadvantage has been included, only those that seemed most likely. In particular, in space-opera, supers or horror settings, variant racial templates can include pretty much any ability that can be rationalized as "genetic,"

Human Eugenics: Breeding Programs (Continued)

In theory, a eugenic breeding program could eventually produce "racial templates" that include any hereditary advantage or disadvantage within the human genome (see *Eugenic Germline Gengineering,* p. 25). It could only bring out and emphasize features that are latent in existing genes, not create completely new capabilities ("species modification").

There's no way to predict how long this process would really take. GMs who want hard numbers could assume that a large, intensive and ruthless breeding program just might be able to put about 1d-4 (at TL1-5), 1d-3 (at TL6) or 1d-2 (at TL7+) character points towards creating a specific genetic template every generation. Keep track of *negative* points as well – apply them toward hereditary disadvantages, representing inbred traits.

At TL7+, this averages 1.5 character points per generation; so, for instance, breeding a "warrior caste" who all possessed Combat Reflexes (15 points) would take about 10 human generations. These represent total points of change, so Weak Will (-8 points) and High Pain Threshold (10 points) is 18 points, not 2 points. A eugenics program will probably also produce several "failures," who may have interesting but unplanned advantages or disadvantages.

Someone who is the living product of an ongoing eugenics program might represent centuries or millennia of effort by a powerful organization. As such, they might well be the victims of plots to subvert, kidnap or assassinate them. The Social Stigma "valuable property" is appropriate for any eugenics subject.

Eugenics programs are especially suitable for ***GURPS Illuminati*** settings, where secret societies may indeed have long-running and manipulative interest in certain "bloodlines," which might translate into eugenics. In alternative history settings where the Axis won World War II, such as "Reich-5" (see ***GURPS Alternate Earths***), eugenics programs may also be underway. GMs interested in SF examples of eugenics programs should definitely check out the works of SF author Frank Herbert, notably *Dune* and *Hellstrom's Hive.*

Why Make Ubermenschen?

Genetic engineering to allow superhuman physical feats is useful for many physically-demanding jobs, but especially for covert operations, where bionics or powered suits might be too easy to detect. Modern military forces may also find biological enhancement easier on logistical grounds – a gene-enhanced soldier may not be quite as strong as a robot or suit, but at least he doesn't require any special maintenance.

Since modifications to ST and DX are purely physical, they would be amenable to animal testing. Several models of enhanced "super-animals" were probably designed before any super-humans were. Even if the animals weren't put into production, a few prototype super-critters might be found in (or escape from) labs.

Many species modifications (and to a lesser extent, almost all genetic modifications) produce effects that can be replicated more cheaply by technology. Why bother to use feline genes to give someone fur or claws when you can get the same or better effect with a weatherproof jacket and a knife?

First, parahumans may be designed as frontier colonists or workers on worlds with harsh environments. A biological edge may be useful if disaster leads to a technological breakdown. Even if it doesn't, being able to survive outdoors (even briefly) without artificial aids brings a welcome sense of security, contributing to the psychological health of the community.

Continued on next page . . .

from mouse-sized humans to the ability to throw lightning bolts or fly faster than light. In that sort of campaign, don't feel bound by tech levels – after all, in the comics, a genius grad student working in a late-TL7 lab might splice "spider genes" into human germ cells and grow a human/spider chimera with ST and DX bonuses, Clinging, Extra Arms and Webbing.

Gengineered Attribute Modifiers

Attribute modifiers are used to determine the attribute scores of an *average* member of a race whose mean attribute scores differ from the human norm of 10. Thus, a variant race with an attribute modifier of ST+1 will, on average, have ST 11. A variant race with a particular attribute bonus, like ST+1, has undergone genetic alterations to make its strength, dexterity, intelligence or health superior to the human norm; a penalty indicates modifications that have made it inferior. See p. CI175 for further details on attribute modifiers.

What actual changes might be needed to achieve this? Here are some possibilities:

Strength

ST may be enhanced by eugenic modifications to ensure a hefty build. Alterations to the endocrine system may promote growth of muscle over fat. The structure of both voluntary and involuntary muscle tissue can be modified with more or stronger fibers. Species modification may actually improve the bones themselves, increasing their structural strength and allowing stronger attachment points for muscles. At high TLs, alterations to the mitochondria (see *Eve, Eukaryotes and Organelles,* p. 8) might improve the way the body uses its own energy resources.

Dexterity

DX may be improved by eugenic modification to ensure an athletic body type, or at high TLs, by modifying nerve fibers and the spinal cord for faster nerve impulse transmission.

Intelligence

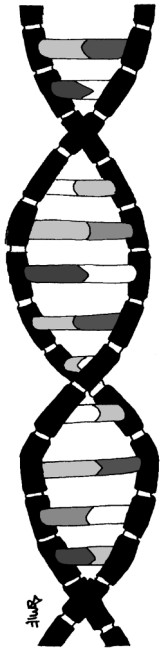
IQ may be improved by subtle neurological changes (see *Brain Modifications,* p. 32) or by increasing brain surface area. These are delicate procedures, requiring sophisticated neuropsychological and genetic science, and are probably impossible before TL10. Species modification may actually increase the size of the brain.

Health

HT may be increased by a spectrum of genetic changes, ranging from eliminating genetic defects and hereditary tendencies toward degenerative illness to gengineering away the appendix. Species modification to produce high racial HT bonuses may physically alter internal anatomy, especially the cardiovascular, respiratory, gastrointestinal and immune systems.

Gengineered Attribute Bonus Table

Type	Amount	Cost	TL
ST Bonus:			
	+1	10	8
	+2/+3/+4	20/30/45	9
	+5/+6/+7	60/70/80	10
	+8/+9/+10	90/100/110	11+
DX Bonus:			
	+1/+2/+3	10/20/30	9
	+4	45	10
	+5	60	11+
IQ Bonus:			
	+1/+2	10/20	10
	+3/+4	30/45	11+
HT Bonus:			
	+1	10	8
	+2	20	9
	+3/+4	30/45	10
	+5	60	11+



The table shows the maximum attribute bonuses a gengineered variant human race should have at a given TL.

If further gengineering is applied to an existing variant race, the limits remain based on the *original* species, and represent fundamental physiological, psychological or technological limitations. Thus, you can't get around the maximum of IQ+2 at TL10 by engineering a variant race with an average IQ 12, then gengineering it again and again to give it even higher IQs. The assumption is that humans have a basic set of limits the human form must fall within. As gengineering improves in TL, humans can be pushed closer and closer to those limits. It is impossible to go further without fundamentally altering the human form itself.

Bonuses over +3 to ST or +2 to other attributes require species modification: the recipient is no longer entirely human. Species modification can also allow ST bonuses under half the maximum for a particular TL to be achieved without visible increase in bulk, through redesign of muscle and bone tissue.

Attribute *penalties* down to -3 (or -5 with species modification) are possible, representing either genetic flaws tolerated in an otherwise good design, or the results of aiming for a specific build. For instance, a heavy frame might give high ST but low DX, with the reverse being true of a sub-race that is designed with a small or light frame.

Non-Human Strength: When gengineering a species that starts with ST other than 10, the maximum alteration (see the table above) is expressed as a *percentage* increase: +10% per +1 on the table. For example, at TL9, an elephant (ST 300) is not limited to +4 ST; it could be modified for an extra ST +120 (since 40% of 300 is 120). This rule also applies to Extra or Reduced Hit Points.

Gengineered Advantages

The following sections discuss changes that might plausibly be bioengineered into a variant human race to produce various advantages (a few associated disadvantages are also included; see *Gengineered Disadvantages,* p. 51, for more). Rather than repeat the racial generation rules in yet another ***GURPS*** supplement, we've assumed familiarity with this system, as presented in ***GURPS Aliens, Blood Types, Compendium I, Fantasy Folk*** and ***Uplift,*** and have instead included only the point costs and names of advantages or disadvantages, plus page references to ***GURPS Basic Set*** or ***Compendium I.***

Why Make Ubermenschen? (Continued)

Second, some cultures may prefer "softer" biotech to inorganic devices, or create transgenic people for aesthetic reasons.

Third, biological abilities are more convenient. Someone with super-acute senses doesn't need to stop to look at an instrument to know if someone's sneaking up on him. Likewise, you don't have to worry about changing the batteries. If you have retractable claws, you'll never forget your knife or puzzle over concealing it in different types of dress or undress. Sure, you can get the same effect with cyberwear or neural interfaces, but that's as expensive as riding the genemod train.

Fourth, transgenic modifications can be augmented as well. If you've got natural claws, no one says you can't add a diamond layer to them. If you have super-sensitive hearing and smell, you can use them at the same time you're wearing that macrovisor. It's not an either/or proposition – it's a wider range of capability.

Nature vs. Nurture

There is an ongoing scientific debate over the relative degree to which human traits and behavior are influenced by genes ("nature") and by environmental factors ("nurture") in the womb and in childhood, including child care, nutrition, education and other life experiences.

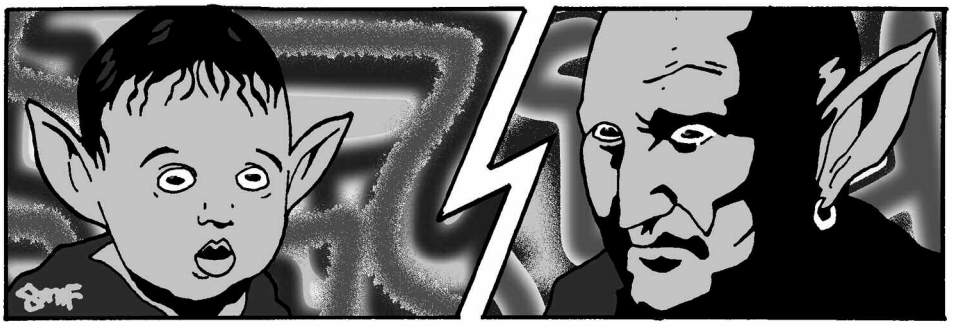
It is important to stress the profound effect that events in the womb have on the physical and mental traits of a person. While genetic disorders can cause many physical disadvantages, many other physical abnormalities – including many gross deformities – can result from problems that arise during fetal development, such as the lack of oxygen at a crucial time, or the presence of radiation or chemicals.

The childhood environment is similarly influential. For instance, there is a convincing body of research that suggests the trait of "shyness" is genetic. Certain genes *do* make people extra-cautious and anxious, leading to high heart rates when responding to new stimuli. This influences behavior through a kind of feedback loop. To escape these feelings of anxiety, children with these genes avoid new situations where these kinds of stimuli occur – they act "shy." However, studies also indicate that parents who encourage their shy kids to play with others at an early age will actually alter these biochemical systems, modifying the way the body reacts to stimuli. In other words, nurture triumphs over nature through deliberate action.

Likewise, while it is possible to edit out genes believed to influence mental instability, many mental disadvantages result from childhood trauma. Thus, while someone may not have the genetic predisposition toward lecherousness, he may have grown up in an emotionally deprived environment which led him to adopt promiscuity as his sole means of expressing affection. Similarly, someone who saw his parents massacred in a war may be prone to fits of uncontrollable rage, or manic-depressive episodes.

In short, it's hard to eliminate common mental and physical problems just by fixing genes. If gengineered people are grown in an artificial womb (growth tank or forced-growth tank) and educated under controlled conditions, then they *may* turn out exactly as planned. On the other hand, if they are born of a real womb and grow up in the real world, there is a fair chance that they'll have the same sorts of problems as everyone else.

Continued on next page . . .



The assignment of TLs and association of advantages with various traits (e.g., Hard to Kill under *Cardiovascular Modifications*) are suggestions only, and may be altered by the GM as desired.

Eugenic vs. Species Modification: Whether added DNA sequences are human or not may be very important if society bans or stigmatizes parahumans. Also, species modifications are more likely to be coupled with nonhuman features. Those genetic advantages that would probably require departing from the human genome have been labeled as "species modifications."

Brain Modifications

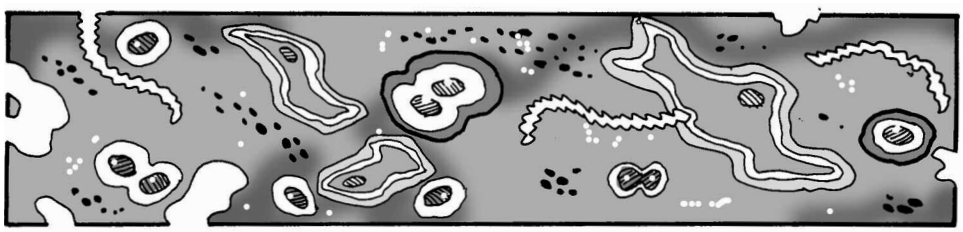
"Our competitors at Matsai gengineered their 3000-series megabrights for hyped-up creative, intuitive and mathematical faculties. Turned out the gengineers didn't know as much as they thought they did about brain chemistry, and ended up with three super-bright, high-strung, delusional schizophrenics. Two killed themselves. The third is convinced God is behind the event horizon of the black hole in the galactic core, and devotes all her time to trying to figure out how to get him to answer back. She's managed some useful astrophysics and hyper-mass experiments, but that isn't what Matsai hoped for. Still, Matsai corporate ideology keeps them trying to develop 'super-thinkers.' I admit they did a better job with their more modest Pandora-series, although these sure aren't bug-free either – ever try talking to one?"

– Doctor Sayyid Iqbal, Biotech Euphrates

Attempting to gengineer mental traits such as intelligence, alertness, memory or specific aptitudes is difficult, because these traits are much more abstract than physical ones. Exactly how much of "intelligence" is genetic and how much is environmental is not only controversial, but any answer also depends on how you measure and define intelligence.

However, traits ranging from self control to high intelligence appear to be at least *partially* the result of specific gene sequences that govern the exact mix of hormones and other neurotransmitters produced by the body. As of 1997, scientists have found human genes that appear to correlate with mental stability, shyness, impulsiveness (which, by mitigating it, may lead to Common Sense) and memory, among other things.

In this realm, gengineering works hand in glove with neurology and molecular neuropsychology. Today, radioisotope-labeled monoclonal antibodies (p. 17) are used to locate neurotransmitters in the brain. At TL9 or higher, nanomachine probes can actually observe the brain's neurochemical activity as it occurs. By studying what molecular changes take place while staying awake, enduring pain, memorizing, solving a math problem, et cetera, bioengineers may be able to design nucleotide sequences that will optimize the brain's neurochemistry or structure toward specific activities.



Brain Modifications

Name	Cost	Page	TL
Alertness	5/level	B19	9*
Ambidexterity	10	B19	9
Autotrance	5	CI20	9
Eidetic Memory	30/60	B20	9/10
Lightning Calculator	5	B21	9
Mathematical Ability	10	B22	9
Single-Minded	5	CI30	9
3D Spatial Sense	10	CI31	10
Chronolocation	15	CI21	10
Common Sense	10	B20	10
Intuition	15	B20	10
Intuitive Mathematician	25	CI26	10
Language Talent	2/level	B20	10*
Musical Ability	1/level	B22	10*
Versatile	5	CI31	10
Species Modification:			
Compartmentalized Mind	50/level	CI52	11**

* Add +1 to TL for every level of this advantage after the first five levels.
** Add +1 to TL per level after the first.

Sleep-State Modifications

The exact biochemical mechanisms behind sleep remain somewhat murky. Many researchers believe that animals (including humans) sleep and dream because the body or brain needs time to rest and regenerate itself. However, some scientists lean toward the idea that sleep is not a metabolic necessity, but rather an evolutionary quirk. That is, our brains are programmed to make us sleepy because being dormant for a certain length of time reduces food requirements and, for humans, prevents us from stumbling into predators we can't see. If that's the case, sleep's been obsolete since we invented fire – unfortunately, the only way to tell our bodies otherwise may be genetic engineering.

Careful tinkering with sleep-regulating structures in the brain, such as the caudal brain stem, basal forebrain, the serotonin-producing raphe nuclei and the suprachisamatic nuclei (which appear to govern circadian rhythms) may modify or eliminate the need for sleep. Other modifications may affect the way humans dream by interfering with the flow of images to the cortex from the limbic centers (the older part of the brain).

Sleep-State Modifications

Name	Cost	Page	TL
Deep Sleeper	5	CI23	9
Less Sleep 1-5	3/level	CI27	9
Sensie Talent	2/level	CI30	10
Racial Skill Bonus:			
Lucid Dreaming +1-3	0.5/1/2	CI142	10
Dreaming +1-3	4/6/8	CI139	11
Species Modification:			
Reduced Sleep	10	CI64	10
Doesn't Sleep	20	CI53	11

Cardiovascular Modifications

Cardiovascular modifications are made to the heart, blood and circulatory system. The heart may be strengthened with enhanced muscle tissue so it can better withstand trauma and stress, providing the advantages Extra Hit Points, Fit, Very Fit or Hard to Kill.

Nature vs. Nurture (Continued)

In game terms, this means that most mental advantages, disadvantages and taboo traits in a genetic racial template should be considered guidelines rather than hard-and-fast rules. If the subject was raised in controlled conditions, and no mistakes were made, he'll generally "live up to spec." Of course, it's also possible that a human who is gengineered for a specific trait may have had those genes artificially *enhanced* to a degree that makes it much more likely he'll develop it.

Miniature Humans

Modification of genes governing human growth factor can create pint-sized parahumans who, as adults, are the size of young children, smaller than ordinary genetic dwarves. Creating miniature people has some obvious advantages: they'd take up less space (especially useful for military or space vehicle crews) and require less life support. However, there are some serious physiological obstacles to producing doll-sized humans.

First, we define "humanity" in terms of intelligence. The human brain's thinking capacity depends on having a certain minimum size and mass. You can shrink the body but not the head, as in a human dwarf, but there is a limit to how big a head can be supported on a shrunken neck and spinal column without causing problems. Alternatively, if the size of the head is reduced proportionately with the rest of the body, intellectual capacity will decline. Fortunately, intelligence appears to be a function of brain area rather than mass or volume, so reducing brain mass does not result in a direct, linear drop in IQ.

Second, a scaled-down human loses heat more rapidly, due to his larger body area in relation to his mass. This means he will need to eat more in proportion to a normal-sized human just to keep his body temperature up. (This is why small mammals like mice are almost always either eating or sleeping.) Even so, overall food consumption will be lower. It might be a good idea to add fur (to preserve heat) or a longer sleep cycle to any miniature human.

Continued on next page . . .

Miniature Humans (Continued)

Third, while a smaller size is handy in terms of reduced life support requirements, it is also inconvenient for many other activities, from reaching things on a shelf to finding clothes that fit. It also correlates with reduced ST and hit points.

Miniature Human Templates

Realistic miniature humans should have these advantages and disadvantages:

Miniature Attributes Table

Scale	*ST*	*IQ*	*HPs*	*TL*
1/2	-5	-1	-5	8
2/5	-6	-2	-6	9
1/3	-7	-3	-7	10
1/4	-8	-4	-8	11

Scale: The reduction in overall proportions, including the body's height, breadth and thickness. It is also the proportion of air, food and water the miniature consumes on a daily basis compared to a normal human – multiply cost of living and any life-support requirements by this amount.

ST, IQ and HPs: Suggested racial attribute modifiers for that scale. These limits can be exceeded by modifying the muscles, skeleton or brain using gengineering, as described under *Gengineered Attribute Modifiers* (p. 30). However, the maximum increase allowed at each TL should be multiplied by scale. For instance, TL10 gengineering allows up to +7 ST; in a 1/3-scale human, this would be reduced to a mere +2 bonus, which mean a 2' tall superman would be limited to a ST modifier of -5.

TL: The minimum TL required. "Miniaturization" counts as a single feature of that TL for gengineering purposes.

Other Advantages and Disadvantages: Miniatures should have these advantages and disadvantages: Decreased Life Support (10 points), Fur (4 points, optional but common if 2/5 scale or less), Gluttony (-5 points) and Reduced Hit Points (see above, -5 points per -1 hit point). If 1/3 scale or less, Inconvenient Size (-15 points) should also be taken.

Continued on next page . . .

Bone marrow cells may be modified to produce gengineered blood cells with improved capabilities. The hemoglobin in red blood cells (*erythrocytes*) can be redesigned for greater oxygen transport capacity (Extra Fatigue). Extra red blood cells can be stored in the spleen (as in a dog) for additional release when necessary. *Platelets* may be modified for superior wound clotting ability (Rapid or Very Rapid Healing).

Arterial tissue may be gengineered so it does not lose its elastic property with age (which could provide Longevity). More specialized cardiovascular genemods are also possible. For instance, as high-g acceleration causes blackouts when the blood pools in the lower body rather than reaching the brain, arteries feeding the lower body may be redesigned to react to g-forces by pinching off blood flow to legs and abdomen while enhancing it to the brain (Acceleration Tolerance). Related modifications may produce faster recovery from unconsciousness (Recovery) or adapt the circulatory system to lengthy periods in higher or lower gravity (Improved G-Tolerance).

To design cardiovascular genemods, use these advantages:

Cardiovascular Modifications

Name	Cost	Page	TL
Acceleration Tolerance	10	CI19	9
Extra Fatigue 1-5	3/level	CI24	9*
Extra Hit Points 1-3	5/level	CI24	9*
Fit	5	CI25	9
Hard to Kill 1-3	5/level	CI25	9*
Longevity	5	B21	9
Rapid Healing	5	B23	9
Improved G-Tolerance 1-3	5/10/15	CI26	9/10/11
Recovery	10	CI64	10
Very Fit	15	CI31	10
Very Rapid Healing	15	CI31	10

* +1 to TL for every level after the first three or five.

Cosmetic Modifications

Hair and eye color can be specified quite easily, as they are governed by single genes. Skin pigment (melanin) and other traits that make someone racially black, Caucasian, and so on, are governed by multiple genes. These can be selected at TL8+ to give whatever skin color or other ethnic features are desired, or to deliberately blend several types. At TL10+, exotic features like green hair, blue skin or gold-flecked eyes may be possible.

Good (or bad) looks can be selected by choosing a particular bone structure and metabolic factors that encourage a specific type of build, while working against acquiring blemishes, acne and so on. Left unspecified, a person's looks are whatever is randomly inherited from the original genetic material used, i.e., it depends on the parents, and it's up to the player or GM.

Transgenic Features (TL9): If genes are taken from other species to produce certain effects, they may also alter appearance. For instance, a person with Discriminatory Smell and Ultrahearing from dog genes may have a

canine nose and ears. Such features could be accidental or deliberate, or a bit of both. When calculating the difficulty of gengineering, assume that something like "canine features" counts as a single feature.

Genetic Tattoos (TL10): These are images or symbols formed from skin pigmentation, bumps or ridges. They might be artistic, or show clan or company affiliation – a slave race might even have a tiny company logo and "TM" on their body. Also at TL10, introns can be modified to "spell out" specific messages when someone sequences the gengineered DNA – see *Junk DNA and Gengineering* (p. 10) for an explanation of introns.

Cosmetic Modifications

Name	Cost	Page	TL
Appearance	5/15/25	B15	9
Pitiable	5	CI29	9
Racial Skill Bonus:			
Sex Appeal +1-3	1/2/3	B64	9
Species Modification:			
Transgenic Features	0	–	9
Genetic Tattoos	0	–	10
Intron Messages	0	–	10

Gastrointestinal Modifications

"Chronos-series long-range recon patrol bioroids have a stomach like a grasshopper mouse's and hyperactive digestive enzymes that can digest anything. Supposedly, that frees them from dependence on the supply system, especially in harsh environments where there isn't much food around. In the Andes conflict, I saw them ambush an enemy patrol, then swallow them up and grind them down, bones and all. Even ate their own dead. Creepy."

– Captain (ret.) Dana Martello, Marine Force Recon

Colonists, scouts or soldiers who have to live off the land might have an intestinal tract redesigned to function like that of a ruminant animal (e.g., a cow), with symbiotic bacteria that can digest cellulose, allowing them to eat almost anything. This gives either Cast Iron Stomach or Universal Digestion.

Going the other way, it might be desirable to *remove* as much parasitic and symbiotic bacteria as possible from the human body. Spacers may take this route to reduce the risk of bacterial infection or mutation in fragile and radiation-exposed space ecosystems. If so, the newly-sanitized intestines will need to be modified to produce enzymes that handle the functions of intestinal bacteria, such as vitamin synthesis. This would give Sanitized Metabolism.

The vermiform appendix is a vestigial growth on the end of the intestine. In humans, it doesn't do much except become easily infected; human gengineers may choose to remove it in the interests of boosting overall health and resistance to disease. In and of itself, this is only a feature (no point cost), but it is often taken in conjunction with an overall increase in HT.

Gastrointestinal Modifications

Name	Cost	Page	TL
Species Modification:			
No Appendix	0	–	9
Sanitized Metabolism	5	CI65	9
Cast Iron Stomach	15	CI51	10
Universal Digestion	15	CI69	11

Glandular Modifications

"Well, sir, we've been grown with the Gen-Five supergland. Whenever our model goes into overdrive, we get these ***cravings*** *afterward. No, sir, we didn't mean*

Miniature Humans (Continued)

Weight, Area and Meals Table

Scale	*Weight*	*Area*	*Meals/Day*
1/2	1/8	1/4	4 (1.5)
2/5	1/16	1/6	6 (1.2)
1/3	1/27	1/9	9 (1)
1/4	1/64	1/16	16 (0.75)

Weight is in comparison to an average human of similar build. To determine a miniature's actual height and weight, find what his ST would be if there were no racial ST penalties (p. B15), determine height and weight from that, then multiply that height by scale and that weight by the weight number shown on the table.

Area is the body's surface area compared to a human. Multiply the cost and weight of clothes or armor for the miniature by this amount.

Meals/Day: This is the number of separate meals that the person would normally have to eat in an average day. However, each individual meal is scaled down in proportion to the weight of the miniature (e.g., a 1/2-scale miniature eats a 1/8-sized meal), which is why the overall cost of living is less. The daily equivalent in human-sized meals is in parenthesis, e.g., four meals for a half-sized character equal 1.5 human meals a day.

Alpha-Series Upgrade (TL9)

DX +1 (10 points), HT +1 (10 points).

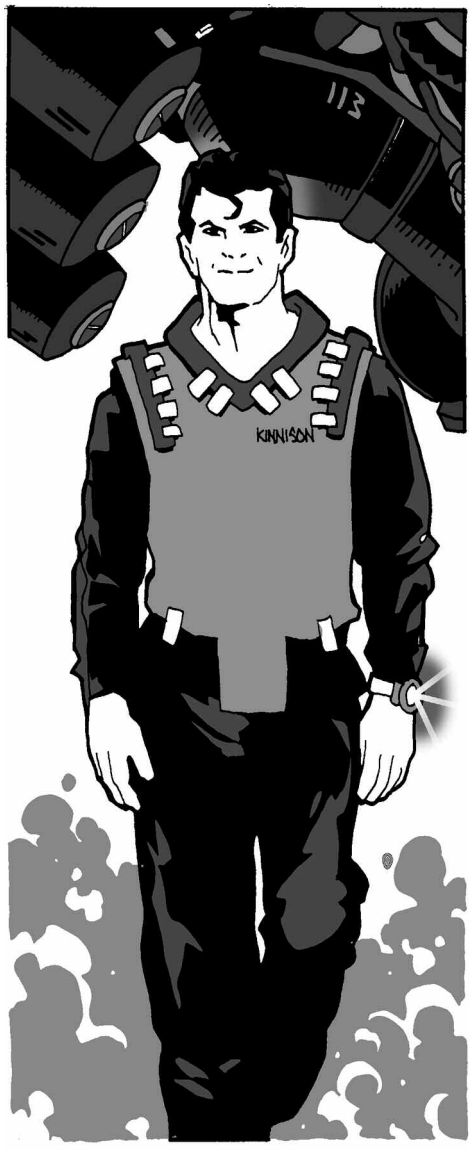
Racial Advantages: Attractive (5 points), Disease-Resistant (5 points), Longevity (5 points).

Racial Disadvantages: None.

Features: Taboo Traits (Genetic Defects, Mental Instability).

Racial Cost: 35 points.

Careful eugenic improvements ensure an attractive, athletic, healthy individual. Medscanning may reveal minor "mutations" compared to the human norm, such as being born without an appendix. This is a simple *"Homo superior"* genotype that TL9+ parents – or societies – might select for their children.



to do that to the prisoners, but we just couldn't help ourselves. Usually the MPs are on hand, but – yes, sir, I'm sorry, sir."

– Corporal NB-SEK-0172-BUR84, 152nd Paratroop Regiment, female Felicia-series bioroid

A network of internal glands, the *endocrine system,* secretes hundreds of different hormones into the bloodstream. These hormones regulate the body's growth, development and routine metabolic processes, as well as emergency, emotional and sexual responses. Selective glandular biomodification can optimize the body's hormonal balance so that a person will develop in a certain way (more muscular, for instance), perform differently under stress, or experience stronger or weaker passions.

Gengineering of the hypothalamus, pituitary and thyroid glands, or designing new, voluntary regulatory glands that produce similar hormones, could adjust metabolic processes such as growth and maturation, permit increased activity (at the cost of greater food consumption), or possibly allow control over normally involuntary biological functions like respiration and digestion.

It may also be feasible to engineer for short-term "emergency performance" or to improve stress response in general. One goal would be to allow voluntary control of the sudden bursts of "hysterical" speed or strength that some people are capable of in emergencies. This might require genetic tinkering to modify the adrenal glands or, as with metabolic control, the creation of new voluntary glands that produce similar hormones. This would be represented by Hyper-Strength or Hyper-Reflexes, or by advantages like Combat Reflexes and Increased Speed.

By tinkering with hormones, the gengineer can also adjust human behavior, creating a variant human whose emotions are somewhat skewed in a desired direction. Modifications of this sort usually center on the adrenal gland, the gonads (which control influential sex hormones such as estrogens – e.g., estradiol – and androgens – e.g., testosterone) or the pituitary (which produces hormones that influence other glands). The strongest influence will be on the three "primal" human responses: fear, aggression and sexual behaviour.

Glandular Modifications

Name	Cost	Page	TL
Metabolic:			
Early Maturation	5/level	CI53	9*
Hyperactive	30	CI57	9
Improved G-Tolerance	5/10	CI26	9
Metabolism Control	5/level	CI60	9*
for hibernation	2.5/level	CI60	9*
Emergency-response:			
Combat Reflexes	15	B20	9
Hyper-Reflexes	15	CI58	9
Hyper-Strength	30	CI58	9
Increased Speed +1-2	25/50	CI26	9
Increased Speed +3	75	CI26	10
Behavioral:			
Collected/Composed	5	CI22	9
Cool	1	CI23	9
Fearlessness +1-5	2/level	CI25	9
Imperturbable	10	CI26	9
Unfazeable	15	CI31	9

* +1 TL for every two levels after the first.

Limitations: Tinkering with glandular systems is tricky, and design compromises are often made by the gengineer. These can be represented by taking one or more of these limitations on glandular advantages: Chemical Trigger (p. 137), Emergencies Only (p. CI110), Limited Use (p. CI111) or Nuisance Effect: Temporary Disadvantage (often Bad Temper, Berserk, Gluttony or Lecherousness; see p. 137).

In addition, emergency-response modifications also often have Cardiac Stress (p. 139), Costs Fatigue (p. CI110), Uncontrollable (p. CI112) or Unreliable (p. CI112).

Pheromone Modifications

I believe that we can gain further control over the next generation by restoring the vestigial vomeronasal system, which reacts to airborne pheromones. Unlike lower animals, whose pheromone vulnerability is limited by mating seasons, humans with this genemod may experience irregular, heightened states of arousal. More important for our purposes, they will become far more vulnerable to enhanced pheromones, such as those produced by the pheromone glands and aerosols we have developed.

– Dr. Tse Chang, *Report to the Genetic Planning Council*

Pheromones are chemical signals given off by the body's natural secretions. Animals use pheromones to attract mates or, to a lesser extent, warn others of danger, identify each other or establish dominance. Many other animals have a vomeronasal organ that lets them perceive pheromones as a feeling rather than a smell: detecting another's pheromones can induce arousal, attraction, respect, nervousness or whatever. In humans, the vomeronasal organ has atrophied to the point where people probably can't detect pheromones.

Various pheromonal genemods are possible at TL9+:

Sex Pheromones (TL9): Modified human glands could produce sex pheromones powerful enough to influence humans. This is the advantage Pheromone Control (25 points, p. CI63).

Dominance Pheromones (TL10): These are bought as a reaction bonus or Charisma, with the limitation Scent-Based (-20%; see p. 138).

Restored Vomeronasal Organ (TL10): This is bought as one or more levels of Weak Will, only to resist pheromones or seduction attempts (-75%), -2 points/level.

Other disadvantages might also be triggered by pheromones – see the Only vs. Pheromones limitation (p. 138) for details.

Immune System Modifications

The body responds to invaders by producing white blood cells (*leukocytes*): *B-cells* (formed in the spleen, blood and lymph nodes) tag invading cells with antbody proteins so that killer *T-cells* (formed in bone marrow) can recognize and attack them. Improved disease-resistance may result from gengineering the spleen and bone marrow to manufacture more discriminating and aggressive leukocytes. Ultimately, they may be engineered into bio-nanomachine factories, creating cells that can do everything from binding with and destroying toxins to cleaning out clogged arteries (Immunity to Disease, Longevity).

Immune System Modifications

Name	Cost	Page	TL
Disease-Resistant	5	CI24	9
Longevity	5	B21	9
Resistant to Poison	5	CI29	9
Species Modification:			
Immunity to Disease	10	B20	10
Immunity to Poison	15	CI58	10

Eros-Series Bioroid (TL9)

ST -1 (-10 points), HT +1 (10 points).

Racial Advantages: Deep Sleeper (5 points), Disease-Resistant (5 points), Light Hangover (2 points), Pheromone Control (25 points), Sanitized Metabolism (5 points), Sex Appeal +3 (3 points), Very Beautiful (25 points).

Racial Disadvantages: Impulsiveness (-10 points), Lecherousness (-15 points), Sterile (-3 points), Unnatural Feature (exaggerated sexual characteristics, -5 points).

Features: Taboo Traits (Genetic Defects).

Racial Cost: 37 points.

A high-end "custom-cutie" design, with an inhumanly perfect body, plus brain, glandular and bacteriological modifications to ensure it is always eager, playful, healthy and disease-free. Grown as a professional courtesan or a rich person's living toy, the Eros can also be the basis for a devastating "Mata Hari" spy.

The Eros-series' exaggerated sexual anatomy is the source of both its Sex Appeal skill bonus and its Unnatural Feature.

Felicia-Series Bioroid (TL9)

ST -1 (-10 points), DX +3 (30 points), HT +1 (10 points).

Racial Advantages: Acute Hearing +2 (4 points), Acute Taste and Smell +2 (4 points), Attractive (5 points), Catfall (10 points), Claws (15 points), Combat Reflexes (15 points), Double-Jointed (5 points), Fur (4 points), Hyper-Reflexes and Hyper-Strength (Nuisance Effect: suffers from Gluttony, Impulsiveness and Lecherousness after use until fatigue is regained, -30%, 32 points), Night Vision (10 points), Perfect Balance (15 points), Sharp Teeth (5 points).

Racial Disadvantages: Extra Sleep (one hour, -3 points), Overconfidence (-10 points), Reduced Hit Points -1 (-5 points), Self-Destruct (-20 points), Short Lifespan 3 (-30 points), Sterile (-3 points), Unusual Biochemistry (-5 points).

Racial Cost: 78 points.

This is an expensive, feline-model bioroid resembling a lithe, anthropomorphic cat. It is designed for superhuman grace, speed and reflexes, and also possesses upgraded sensory abilities. Felicia-series bioroids are usually employed at jobs that might demand a quick burst of activity rather than strength and staying power. Thy are also physically attractive, making them in vogue as athletics or aerobics instructors, dancers, personal pilots, chauffeurs, bodyguards or even bodyguard/courtesans. Military and police forces may also employ the Felicia-series as aerospace pilots or hostage-rescue troopers.

There's an unintended glitch in the Felicia: after triggering an emergency-overdrive response, glandular imbalances sometimes result in mood swings and heightened appetites.

Lifespan and Self-Repair Modifications

The search for longevity is likely to be a major preoccupation of eugeneering. "Dying of old age" seems to result from numerous factors, each of which must be dealt with separately: arterial clogging, weakening bones, cancers, diseases, accumulated genetic copying errors, and even the progressive depredations of brain-destroying prions. Any genemod that treats even a few of these factors may increase lifespan, but there's also evidence that some cells seem to accumulate copying errors after a certain number of replications (the Hayflick limit). If that's the case, a "revised Hayflick limit" genetic sequence, designed to produce more robust cells, might be needed in order to grant Extended Lifespan or, at TL11+, Unaging.

Actual regeneration is trickier. Gene sequences copied from lizards (which can often regenerate tails or other extremities) may give humans a similar ability. True immortality may require radical alterations to cell structure, or a colony of symbiotic bio-nanomachines that patrol the body (see Chapter 3).

Immune system modifications (p. 37) are closely related to lifespan and self-repair modifications – someone who is immune to toxins and disease is likely to live longer, for example, so these advantages are often found in conjunction with Unaging or Longevity. Immunity to poison and disease (TL10) are logical prerequisites for TL15+ advantages like Immortality and Undying.

Lifespan and Self-Repair Modifications

Name	Cost	Page	TL
Longevity	5	B21	9
Rapid Healing	5	B23	9
Very Rapid Healing	15	CI31	10
Species Modification:			
Extended Lifespan	5/level	CI54	10
Regeneration, slow	10	CI64	11
Regrowth	20/40	CI64	11/12
Unaging	15	CI69	11
Regeneration, regular	25	CI64	12
Regeneration, fast	50	CI64	13
Regeneration, instant	100	CI64	14
Immortality	140	CI58	15
Undying	175	CI69	15

Liver and Kidney Modifications

"Uh, should all of us be drinking? I'm out of Sober-Ups, and we don't have a designated driver."

"Hey, it's cool. I'm an Ishtar-sequence upgrade. With my genemod liver, I can drink all night and never get wasted."

"Well, I hope you've got a boosted kidney, too. It's twenty miles to the nearest rest stop, and I'm not going into this place's washroom without a gun."

Modifications to the liver are usually aimed at selectively improving its metabolization and detoxification abilities, giving better resistance to the effects of blood

poisons, usually in conjunction with modifications to the spleen and kidneys. It may also be possible to rebuild the liver so that its tissues can store oxygen.

The kidneys could be remodeled after a desert animal to conserve water via super-concentration of the urine (which would also reduce the need for bathroom breaks), giving Decreased Life Support.

Liver and Kidney Modifications

Name	Cost	Page	TL
Alcohol Tolerance	5	CI19	9
Light Hangover	2	CI27	9
Resistant to Poison	5	CI29	9
No Hangover	5	CI28	10
Species Modification:			
Decreased Life Support 1	10	CI52	9
Oxygen Storage	14	CI62	9
Immunity to Poison	15	CI58	10

Morphological Changes

No terrestrial vertebrate strays from the fundamental skeletal pattern of a cranium, four limbs and a tail. In some animals, certain of these features are enhanced and others are atrophied – sometimes to invisibility. For example, dolphins replace their legs with flippers and a huge tail, snakes have no limbs, while humans have only a vestigial tail bone, but differentiate their limbs into arms and legs. Nevertheless, the basic pattern remains.

Genetic engineering can alter humans within these limits between TL9 and 10, changing the function of limbs (or deleting them), adding a tail or altering body posture. However, deviating from vertebrate morphology to give humans *more* than four functional limbs, or other exotic changes, requires TL11+.

Modified Limbs

First time I saw the new foreman, I was a little skeptical: a work shack's cramped enough without two extra elbows. That lasted until I saw what Lyra could do in zero-G – we got the new solar panels up in record time. A few days later, Lyra invited me to her apartment, in the station hub where it's always weightless. That night, she showed me another reason to appreciate four hands.

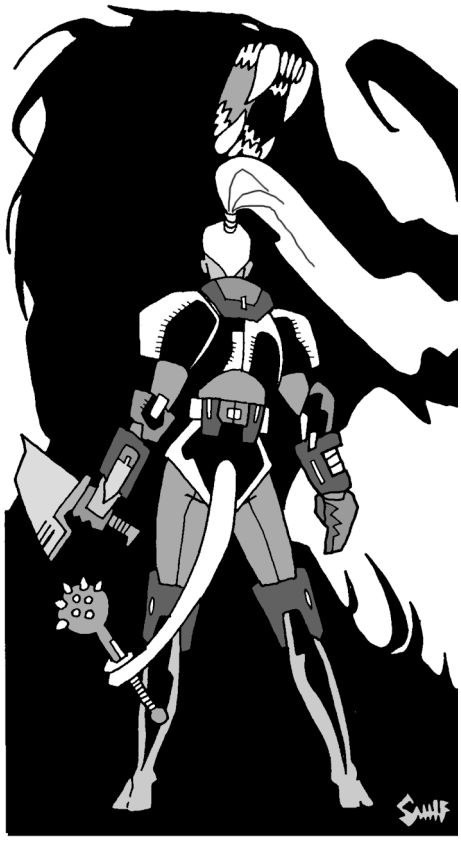
– Copernicus Jones, *Posthumans I've Known*

Digitigrade Posture (TL9): A human's legs can be redesigned to resemble a quadruped's hind legs. Someone with this modification walks on his toes and the ball of his foot, or a hoof. This is usually a cosmetic modification, intended for custom-designed satyrs or other beast-people. While a bit less practical for bipeds than for quadrupeds, careful modification of joints can make this posture just as comfortable. This is a 0-point feature.

Legs to Flippers (TL9): Altering both feet into "frog feet" gives half a level of Enhanced Move (Swimming) (5 points, p. CI54) but at a cost of Reduced Move (Running) -1 (-5 points, p. CI103).

Prehensile Toes (TL9): These are toes that have been lengthened to serve as fingers and equipped with opposable thumbs. This is bought as two short Extra Arms (10 points, p. CI54) with Nuisance Effect: Temporary Disadvantage (Legless while using Extra Arms, -35%), for 7 points. This means that if a person with prehensile toes is using his feet as arms, he can't walk or run; he can still sit, float (in space or liquid) or fly, of course.

Legs to Arms (TL10): Only popular in zero-G, this is a more radical change that replaces both legs with a second pair of arms. Buy this as Prehensile Toes, except that the arms are full length (20 points, or 13 points after the limitation) and give Reduced Move (Running) -2 (-10 points, p. CI103), even when they aren't in use, for a net 3 points.



Heavy Worlder (TL9)

ST +3 (30 points), HT +1 (10 points).

Racial Advantages: Improved G-Tolerance (0.5 G increment, 10 points) with home gravity (p. S36) of 1.5 to 2 G.

Racial Disadvantages: Unattractive (-5 points).

Racial Cost: 45 points.

A heavy worlder's weight is 25% over the human norm, but height is 1' less than indicated for ST. Someone with this modification is wider, which can give problems in narrow passages or doors designed for normal humans (a DX roll to squeeze through).

This is a variant human designed for life in a 1.5 to 2 G environment. He has more muscle to get around, stronger bones to avoid breaking them in falls, and a redesigned circulatory system to prevent early death due to heart failure. Modifications for high gravity are similar to those used for superhuman strength (p. 30), with greater emphasis placed on redesigning the heart and circulatory system for durability. However, the "heavy-worlder" is usually unattractive by human standards, with a barrel chest and a compact, blocky body.

Extra Arms (TL11): Adding one or two real, functional arms (attached between the shoulders and the hips) is much harder than simply transforming legs into arms. Not only are extensive skeletal and muscular modifications required, but blood flow will need to be increased to handle these busy additions, which means a larger heart and more efficient lungs. The nervous system must also be reworked and the brain modified in order to control them.

Except for an extra pair of arms, all of the above modifications are mutually incompatible.

Modified Limbs

Name	Cost	Page	TL
Digitigrade Posture	0	–	9
Legs to Flippers	0	–	9
Prehensile Toes	7	–	9
Legs to Arms	3	–	10
Extra Arms	10/arm	CI54	11

Gengineered Tails

"How'd I get away? Well, Galba's assassin had the drop on me. I set my drinking bulb down on the table behind me and raised my hands. He watched them carefully. He forgot I was a spacer. He wasn't watching my tail."

– Captain Zeke Morrigan, free trader *Antares*

Humans have a vestigial tailbone; species gengineering could use genes from other species to give humans a tail. This might be done for cosmetic reasons, or the tail may be usable as a weapon or a functional extra arm.

Ordinary Tail (TL9): A normal animal tail, with various styles available (cat, wolf, pony, rabbit, rat, et cetera). Clothing should be designed with tail flaps! A 0-point feature.

Prehensile Tail (TL10): A tail capable of grasping, like a monkey's. This is higher TL, as it requires modifications to the brain and nervous system as well. It may be a popular biomod feature for spacers, where an additional grasping limb is always useful. Treat as an Extra Arm with no physical attack (p. CI54; 5 points).

Scorpion Tail (TL12): A segmented tail with a barbed, poisoned tip. Treat as a Striker, reach 1, -4 DX, thrust+1 impaling damage (26 points), with Venom, 3 levels (Limited Use, 4/day -20%, 36 points).

Gengineered Tails

Name	Cost	Page	TL
Ordinary Tail	0	–	9
Prehensile Tail	5	–	10
Scorpion Tail	62	–	12

Winged Humans

"We can synthesize the DNA for feathered or bat-like wings, but you can't just splice wings into a normal genotype and expect it to fly. Thanks to the square-cube law, a set big enough to lift even a child isn't practical. Sure, you can expand the wingspan, but then you end up with wings 50 or 60 feet across. Aside from the inconvenience, you'll run into problems of structural strength and finding the muscles needed to flap them.

"As a result, winged bioroids typically have wingspans of about twice their height. While this can be a visually attractive feature, they have no chance on Earth of flying. I use that cliche deliberately: if you can find an extra-terrestrial environment with a lower gravity but normal or higher atmospheric pressure, then you're in luck. Planets like that are rare, but there are artificial habitats. Our Camazotz-series bioroids were

grown for the domes on Luna City and Titan, and the big orbitals; in under one-sixth G, they really can fly. I imagine if we ever make a Dyson sphere, they'd be perfect."

– Dr. Sayyid Iqbal, Biotech Euphrates

Arms to Wings (TL9): Both arms are replaced with a pair of wings. This gives Flight (40 points, p. CI56) with either the Gliding (-50%) or Winged Flight (-25%) limitation, plus the limitation Requires Low Gravity (-5% per 0.1 G below 1 G, p. 138).

To work out the maximum gravity, take the average ST of the racial template (ST 10 for humans), multiply by 2.5, and divide by the template's average body weight (found from racial ST – see p. B15). Both Skinny and a racial ST penalty are useful disadvantages, as they reduce body weight.

If the wings can still be used as arms when not flying, this is merely a limitation on the cost of Flight; treat as Nuisance Effect: Temporary Disadvantage (No Fine Manipulators, -30%; see p. 137).

If the wings are usable *only* to fly with, then they give the disadvantage No Fine Manipulators (-30 points; see p. CI103), unless they are accompanied by other limbs that serve as arms.

If the wings can double as arms when not flying *and* are accompanied by Extra Arms, buy Extra Arms, but with the limitation Nuisance Effect: Temporary Disadvantage (loss of Flight, -40%; see p. 137).

Angelic Wings (TL12): This is the classical fantasy of wings sprouting from the shoulder blades. It's very hard to gengineer, for the same reasons as adding an extra set of arms – in addition to the problems of arm-to-wing conversion, it requires redesigning the skeleton and adding new muscles and a modified nervous system. Angelic wings give the Flight advantage (40 points, p. CI56), with either the Gliding (-50%) or Winged Flight (-25%) limitation, plus the limitation Requires Low Gravity (-5% per 0.1 G below 1 G, p. 138). Use the formula given for Arms to Wings to work out maximum gravity.

Helot-Series Upgrade (TL9)

Racial Advantages: Disease-Resistant (5 points).

Racial Disadvantages: Weak Will -2 (-16 points), Staid (-1 point).

Features: Taboo Traits (Aggressiveness, Genetic Defects, Mental Instability, Unattractiveness).

Racial Cost: -12 points.

This peaceful and non-aggressive genotype is the result of deliberate gengineering to produce a "tractable" variant race. Helot-series parahumans have been eugeneered to weed out genetic defects and vulnerability to disease, and are fully as intelligent as ordinary humans. However, subtle neurological and glandular modifications have bred rebellious, impulsive and aggressive genes out of the genome – and they are very good at following orders. An unintended defect was some reduction in natural curiosity.

Devolutionary Modifications

Some morphological modifications take a backward step down the evolutionary path, causing humans to revert to more bestial forms. These are most likely intended for the creation of toys or slave races, although a very advanced civilization might enjoy creating blank-minded clone bodies this way, then "uploading" their minds into them as a new experience.

Quadraform (TL9): Chimerization or gene splicing could result in a sphinx-like body, with a human head atop a quadruped animal body (e.g., a leopard or pony), with hands and feet replaced with walking paws or hooves. A quadraform human would have Enhanced Move (Running) 1-2 (10-20 points, p. CI54), but suffer from Horizontal (-10 points, p. CI102) and No Fine Manipulators (-30 points, p. CI103). However, ST is bought at -40% to cost due to the lack of fine manipulators, and the maximum level of ST and Extra Hit Points allowed for human gengineering should be increased by +10 at each TL. The body will take up two or three hexes, and weighs four times as much as a human of the equivalent ST.

Vermiform (TL10): A stranger variation would be a human head on a snake-like body (such as the "lamia" that Tika Dawnstar created; see p. 5). A vermiform human would have the disadvantages Horizontal (-10 points, p. CI102) and No Manipulators (-50 points, p. CI103). However, the advantages Flexibility (15 points, p. CI56) and maybe Constriction Attack (15 points, p. CI52) would be gained. As with quadraform, ST is -40% to cost, and the maximum level of ST and Extra Hit Points is +10. The body will take up two or three hexes, but only weigh the same as a human of the equivalent ST.

Aquaform (TL10): A true "aquamorphic" human may undergo radical gengineering so that the embryo never forms legs, instead developing a fishlike lower body and tail. This would justify Enhanced

Ishtar-Series Upgrade (TL9)

ST -1 (-10 points), DX +1 (10 points), HT +1 (10 points).

Racial Advantages: Alcohol Tolerance (5 points), Beautiful (15 points), Disease-Resistant (5 points), Voice (10 points).

Racial Disadvantages: Jealousy (-10 points), Overconfidence (-10 points).

Features: Taboo Traits (Genetic Defects, Unattractiveness).

Racial Cost: 25 points.

The Ishtar-series genetic upgrade is intended to cater to the desires of parents and creche-groups who want a child optimized for professions such as vid star, dancer, gymnast, pop singer, model and so on. Biotech Euphrates genetechs selected a light, "elfin" build and a facial bone structure that computer-simulations indicated would produce distinctive but highly attractive looks. An extra feature was an augmented liver. In a controversial move, they also deliberately modified the Ishtar neurochemistry with sequences believed to enhance ego and competitiveness. Some believe they went a bit too far . . .

Move (Swimming) 1-2 (10-20 points, p. CI54) at the cost of Aquatic (-40 points, p. CI101).

Centauroid (TL12): A more useful but trickier-to-gengineer variation of quadraform or vermiform would alter chromosomes to blend a human upper body with a bestial lower body, with Centauroid (0 points, p. CI101) replacing Horizontal, and without No Fine Manipulators or No Manipulators. It would still be strong, but would use the *Split ST for Hybrid Races* rule (p. CI176), and only its lower body would benefit from the +10 ST over human norms suggested above.

Musculo-Skeletal Modifications

The BS-2-F Felicia-series combat bioroid is a "special forces" upgrade of our popular AS-2-E, with a wide-spectrum of state-of-the-art improvements. In this vidclip, we see a fire team of BS-2-Fs free-jumping from a helicopter 12 meters up and landing on their feet without injury, thanks to their XM-723 feline morphology.

– Biotech Euphrates promo video at WarEx '47 trade show

"Meow."

– Felicia-series bioroid, upon landing on enemy soldier

Muscular and skeletal modifications are usually aimed at improving physical strength – see *Strength,* p. 30 – but more specialized enhancements are also possible. Modifications to skeletal and connective tissue could provide better-articulated or shock-absorbing joints and vertebrae (Brachiator, Catfall, Double-Jointed) or even longer fingers (Manual Dexterity). At high TLs, organic strengthening of the skeleton itself is possible (Extra Hit Points, Extra Encumbrance).

Bones seem to lose calcium in zero gravity, becoming fragile. GMs can simulate this by requiring a HT roll for every twelve months cumulative exposure to zero-G. A failed roll indicates -1 ST or -1 hit point; a critical failure gives the Fragile disadvantage. Genetic engineering may be used to prevent this problem. "No bone degeneration in zero-G" is bought as Slow Regeneration, only to replace bone decalcification (-75%), 3 points.

Finally, proteins such as resilin (from grasshoppers) might be used to create extra-elastic muscle tissue (Super Jump, although in a realistic setting, only one level of this advantage would be plausible for a human-sized individual).

Musculo-Skeletal Modifications

Name	Cost	Page	TL
Double-Jointed	5	B20	9
Manual Dexterity +1-5	3/level	CI27	9
Toughness	10/25	B23	9
Species Modification:			
Brachiator	5	CI51	9
Catfall	10	CI51	9
Extra Hit Points +1-3	5/level	CI24	9
No Bone Degeneration in Zero-G	3	–	9
Extra Encumbrance	5	CI55	10
Extra Hit Points +4-6	5/level	CI24	10
Extra Hit Points +7-9	5/level	CI24	11
Super Jump 1	10	CI68	11
Extra Flexibility	5/10	CI55	12

Nervous System Modifications (Reflex Boosting)

Alterations to the nervous system could increase nerve impulse transmission rates and thus reaction speed, perhaps by finding superior protein combinations to build nerve fibers out of, or even through the addition of extra neural pathways. However, the built-in speed limitations of electrochemical reflexes – a few hundred miles per hour – make radical improvement difficult without using cyberwear.

More extensive neural modification usually proceeds through quasi-organic enhancements – see Chapter 3. Use of nanotechnology to lay down parallel or replacement electrical nerve pathways may be a more practical – if extremely high-tech – route to super-reflexes than gengineering.

Nervous System Modifications

Name	Cost	Page	TL
Combat Reflexes	15	B20	9
Increased Speed +1-2	25/50	CI26	9
Increased Speed +3	75	CI26	10
Species Modifications:			
Enhanced Time Sense	45	CI54	10
Increased Speed +4	100	CI26	11
Increased Speed +5	125	CI26	12

Limitations and Side Effects: A limitation like Chemical Trigger (p. 137), Costs Fatigue (p. CI110) or Emergencies Only (p. CI110) is sometimes appropriate, as is the racial disadvantage Short Lifespan (p. CI104).

Paranormal Abilities

Abilities like psi powers, super abilities, Magery and Magic Resistance may be gengineered if they have a mapped genetic cause. The TL required is up to the GM, depending on when the genetic basis for the powers in question was discovered. It will require at least TL8 if the paranormal ability is governed by only a few genes, or TL9 if controlled by a large complex of genes.

Respiratory Modifications

No need to wait centuries for atmospheric terraforming to be completed! Colonial Genetics has pioneered this new, high-capacity lung system designed to have your children breathing without a respirator and playing outdoors! Mars Development Corporation will offer a 20% rebate on all lung gengineering as part of the Ares Pioneer program.

– Colonial Genetics press release

Ship malcons and convicts to Mars, then modify the poor bastards' kids so they can't come back to Earth even if they try.

– Professor C. Eric Gideon, soc.culture.mars

Unless they buy the nano to turn them back.

– Deimos Dog, soc.culture.mars

The *lining of the lungs* may produce detoxifying agents to counter or filter respiratory agents. More radically, larger *low-pressure lungs* could be designed that are specialized for breathing in a thin atmosphere, such as a recently-terraformed Mars. Someone with low-pressure lungs would treat very thin atmospheres as thin, thin as standard, standard as dense, and dense or superdense as unbreathable; they would also have a noticeably larger

Lepus-Series Parahuman (TL9)

ST -1 (-10 points).

Racial Advantages: Acute Hearing +2 (4 points), Acute Taste and Smell +2 (4 points), Disease-Resistant (5 points), Early Maturation 2 (10 points), Estrus (0 points), Fur (4 points), Increased Fecundity (0 points), Peripheral Vision (15 points).

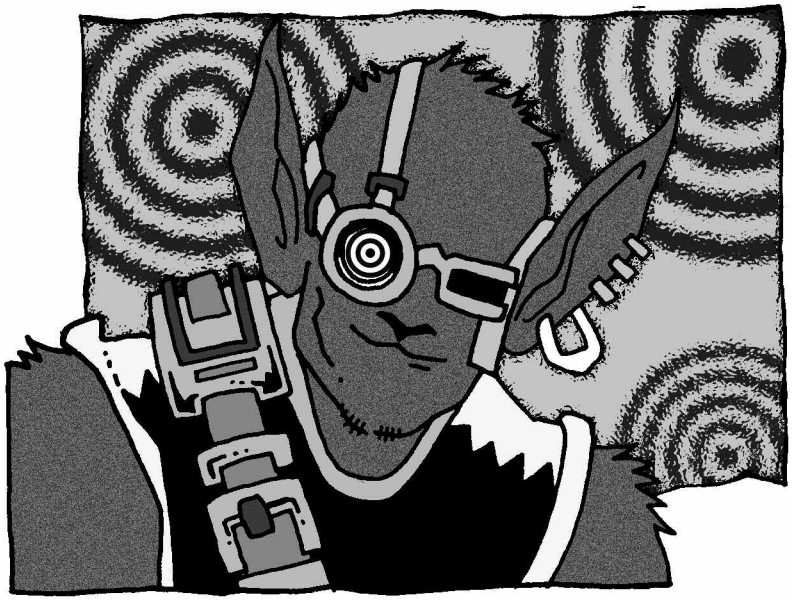
Racial Disadvantages: Color Blindness (-10 points), Lecherousness (only in springtime -75%, -4 points).

Racial Cost: 18 points.

ST -1 and Color Blindness were unintended defects.

These human/rabbit genesplices were originally developed as bioroids by Novabody in the last century, apparently for the domestic, secretarial and pleasure market. A century later, after the War, the Bureau of Colonization resurrected the genotype. BuCon's mandate was to establish "facts on the ground" by repopulating some of the planets depopulated during the War, and by colonizing as much territory as possible. The idea was to send over a seedship with a few hundred "rabbitoid" settlers and a colonial governor's cadre, and within a few years these stable, fast-breeding parahumans would give Earth a thriving agri-world. That was the plan, anyway. Of course, we all know how it turned out.

– Darin Skay, *Shattered Genomes: The Colonial Revolution*



Light Worlder (TL9)

ST -2 (-15 points), HT -1 (-10 points).

Racial Advantages: Longer Arms (+1 reach, 20 points).

Racial Disadvantages: None.

Features: Home gravity (p. S36) is 0.2 to 0.7 G. Increase height by up to 2' over the norm for the lowered ST, but weight is 15% to 25% lower than normal. They can sometimes squeeze into places that normal people can't fit, but this is balanced by their extra height (needing to duck under doors and so on). In settings where artificial gravity is uncommon, this should be worth an extra -5 points.

Racial Cost: -5 points.

Human metabolisms may be genetically adapted for life on planets with gravity significantly lower than Earth's. Generic "light worlder" gengineering results in a willowy build, often with long limbs and spidery fingers.

chest. *High-pressure lungs* would have an opposite effect: atmospheric pressures would be treated as one stage lower. Rules for atmospheric pressure can be found on pp. S75, S108 and pp. CII137, CII144.

A different goal of respiratory modification may be to improve physical performance. Lungs may be give greater elasticity or stronger muscles for superior breath-holding capacity or enhanced gas exchange, with a notable improvement to endurance (Extra Fatigue). A different kind of performance modification would be to alter and improve the windpipe to give someone the Voice advantage, or even a multi-functional larynx capable of Mimicry (perhaps derived from myna-bird genes).

Respiratory Modifications

Name	Cost	Page	TL
Breath-Holding 1	2	CI21	9
Extra Fatigue 1-4	3/point	CI24	9
Voice	10	B23	9
Species Modification:			
Decreased Life Support	10/level	CI52	9*
Extra Fatigue 5+	3/point	CI24	9
Filter Lungs	5	CI56	9
High-pressure Lungs	0	–	9
Low-pressure Lungs	0	–	9
Breath-Holding 2+	2/level	CI21	10*
Mimicry	15	CI60	10

* Add +1 to TL per level after the first.

Respiratory Alternatives

Ever looked at an embryo? It's got gills. Gengineering to retain these vestigial traits should be relatively simple, right?

– Aquagrrl, sci.bio.genemod.human

It's true that human embryos have gill-like structures – but these serve a different function than in fish or amphibians, eventually forming the chin, jaw, cheek and outer ear. As a result, gengineering a merman is a lot more difficult than Aquagrrl implies, especially if we want to breathe both air and water. So far, most dual-environment humans are designed like marine mammals. Navy SEAL bioroids don't use gills. They store oxygen in the myoglobin of the muscles, just like whales do. When drawing oxygen from these sources, their lungs aren't necessary, so they can undergo complete alveolar collapse as water pressure increases, letting them ignore the bends and survive very deep dives.

– DocIqbal, sci.bio.genemod.human

Respiratory Alternatives

Name	Cost	Page	TL
Gills:			
water only	0	CI56	9
air and water	10	CI56	10
Oxygen Storage	14	CI62	9
Pressure Support:			
to 10 atmospheres	5	CI63	10*
to 100 atmospheres	10	CI63	11*
immune to pressure	15	CI63	12*

* Pressure Support is one TL lower if *combined* with Oxygen Storage.

Sensory Modifications

I work with a Border Patrol bioroid whose sense of smell is cranked up. He doesn't need a chemscanner or dog – Duncan can sniff out drugs, explosives, illegals . . . hey, he can even smell a smuggler's fear. Trouble is, Duncan gets these splitting headaches all the time. Just goes to show, if you want a bloodhound's sense of smell, you need a bloodhound's brain.

– Detective Cody Chase, Nevada PD

Engineering the genes governing the development of the rod and cone cells in the eyes, hair cells and membranes in the ears, and the chemical receptor cells in the nose and tongue may enhance basic human senses beyond "perfect" human levels. However, while humans can train themselves over years to develop high "Acute Senses," inborn bonuses over +5 always require transgenic techniques; e.g., ear muscles that swivel independently to more precisely localize a sound. More exotic animal-inspired genemods are also possible:

Absolute Direction can be artificially duplicated by gengineering human brain cells to contain the same kind of magnetite particles that certain migratory bird species possess, forming a biological compass. More extreme versions of this could also give *Magnetic Sense.*

Absolute Timing may be the result of adjustments to the glands that govern the body's circadian clock.

Discriminatory Smell, similar that of a canine or other sensitive-nosed species, could be achieved through enhancement of the chemical receptors in the nose and via modifications to the olfactory lobe.

Field Sense or *Magnetic Sense* may be granted by electrically-sensitive organs modeled on those of electric rays or other fish.

Infravision may be modeled on viper heat organs – subdermal, heat-sensitive pits found next to the eyes on rattlesnakes and similar species. Unless further genetic modification is done to enhance it, this has lower resolution than infrared goggles: -4 to IR vision rolls (-20%), for 12 points.

Night Vision could result from a reflective layer of cells that amplify the light reaching the eyes. These "cat's eyes" could be derived from feline genes. If exotic eyes are unusual, their glittering in dim light could be an Unnatural Feature (only in darkness, -50%). This is worth differentiating from ordinary Night Vision, as the glittering could give away someone's position. A much more complex version of this could lead to *Polarized Eyes.*

Perfect Balance could follow from an inner-ear balance-organ design patterned on those of cats or squirrels.

Ultrahearing could be achieved using ears based on those of canines, bats or other mammals with high-frequency hearing. *Subsonic Hearing* is slightly trickier, but might be based on an enlarged middle-ear cavity, like that of the kangaroo mouse. *Parabolic Hearing* may be achieved using a somewhat asymmetric ear design, similar to that of an owl.

Bat voice boxes are the best models for natural air sonar (*Sonar Vision*), while underwater sonar may be based on that of marine mammals – probably pinnipeds, such as seals, rather than dolphins. Gengineering will have to both alter the voice box and modify (and probably enlarge) the ears to ultrasonic receivers. The complex gengineering required to allow a human brain to directly process sonar images requires a high TL to manage.

Orion-Series Upgrade (TL9)

ST +1 (10 points), DX +1 (10 points), HT +1 (10 points).

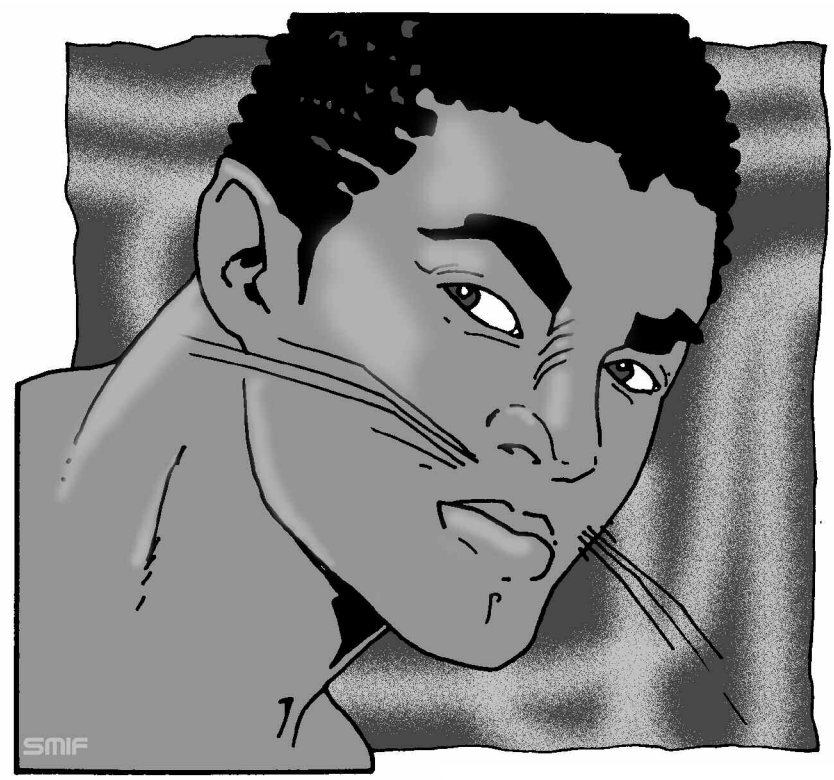
Racial Advantages: Attractive (5 points), Combat Reflexes (15 points), Cool (1 point), Fit (5 points), High Pain Threshold (10 points).

Racial Disadvantages: Attentive (-1 point), Overconfidence (-10 points).

Features: Taboo Traits (Genetic Defects, Mental Instability).

Racial Cost: 55 points.

These genetic upgrades were eugeneered with slight metabolic and glandular modifications designed to burn away excess fat, enhance physical performance and optimize their crisis response. A lot of Orion-series upgrades find jobs in athletics, emergency services, police work or the military, but certainly the best-known Orion-series upgrade is dynamic karate master-turned-megastar Chuck Abrams, whose unchallenged reign as king of the action sensies has had much to do with this genotype's popularity with creche groups and parents.



Whiskers are not merely for show. For example, a cat's whiskers are potent sensory organs for night hunting, capable of detecting air currents flowing around objects. Since this is a completely passive sense that cannot be jammed by most countermeasures, it might be useful for gengineered scouts or warriors (although it requires leaving the face unprotected). This is best represented as Faz Sense with a form of the "Needs Eye Contact" limitation (as described below) to restrict it to a 3-hex range.

However, while these upgrades to human senses are exciting and theoretically possible, there are some problems! Evolution has adapted the human brain toward cognition and away from sensory processing, when compared to the brains of other animals. For example, the olfactory lobe takes up much more of the brain in a dog than in a human. Re-engineering a human with a bloodhound's sense of smell or a dolphin's sonar might turn him into a sensory idiot savant unless a very sophisticated redesign of the human brain is performed. Even so, some disadvantageous side effects are likely (see below).

Spacer Modification (TL9)

ST -5 (-40 points), HT -2 (-15 points).

Racial Advantages: Free Fall +3 (4 points), Slow Regeneration (only to replace bone decalcification, -75%, 3 points).

Racial Disadvantages: G-Intolerance (0.05G increment, -20 points), Skinny (-5 points).

Features: Home gravity (p. S36) of 0 G. Increase height by up to 3 feet over the norm for the lowered ST, but weight is 25% to 50% of normal.

Racial Cost: -73 points.

In micro- or zero gravity, the lack of weight seems to affect development, causing brittle bones. Gengineering may be aimed at modifying the parathyroid gland to restore calcium levels, and otherwise adjusting the metabolism to life in zero-G. Individuals modified for micro- or zero gravity tend to be very tall and emaciated – some "spacers" may be unattractive, while others have an elfin beauty.

Sensory Modifications

Name	Cost	Page	TL
Acute Hearing +1-5	2/level	B19	8
Acute Vision +1-5	2/level	B19	8
Absolute Direction	5	B19	9
Absolute Timing	5	B19	9
Acute Taste and Smell +1-5	2/level	B19	9
Peripheral Vision	15	B22	9
Species Modification:			
Acute Hearing 6+	2/level	B19	9
Acute Vision 6+	2/level	B19	9
Discriminatory Smell	15	CI52	9
Discriminatory Taste	10	CI53	9
Faz Sense	10	CI55	9
Night Vision	10	B22	9
Perfect Balance	15	CI63	9
Subsonic Hearing	0/5*	CI67	9
Ultrahearing	0/5*	CI69	9
Acute Taste and Smell 6+	2/level	B19	10
Infravision	15	CI58	10
Sensitive Touch	10	CI65	10
Sonar Vision	0/25	CI66	10
Telescopic Vision	6/level	CI68	10
Field Sense	10	CI55	11
Magnetic Sense	5/level	CI60	11
Parabolic Hearing	4/level	CI62	11
Polarized Eyes	5	CI63	11

* Ultrahearing and Subsonic Hearing cost 0 points if the possessor is deaf to the normal hearing range.

Limitations: Eye Contact Only (-20%; see p. CI110) can be applied to sensory advantages, even if they don't actually require eye contact, to limit their range to 3 yards. Faz Sense, Infravision and Sonar Vision can all be limited in this way to rep-

resent shorter-ranged (and, in humans, more feasible) forms of these advantages. If so, reduce the required TL by one.

Side Effects: Any species modifications (except Acute Vision, Night Vision, Perfect Balance or Telescopic Vision) are likely to produce disorientation or sensory overload. This may result in one or more of these disadvantages: Confused, Light Sleeper or Migraines. The brain might be able to develop structures to mitigate such problems, although this may also cause a slight drop in IQ or loss of other senses.

Revised Pain Thresholds

I knew I was going to join the ranks of the ethically-challenged when the Sultana offered me twenty grand to create a clone of her ex-husband with a gengineered low pain threshold.

– Dr. Lucien Locke, Genehackers Inc.

Pain sensitivity is vital. People born without it die early – by accident, or from infection resulting from internal joint and bone damage. (They are unable to tell when a particular posture or sleeping position is over-stressing joints or bones, and so do not receive signals to shift weight or otherwise take corrective measures while sleeping or awake.) However, while total insensitivity to pain is not a survival characteristic, the ability to *selectively* block pain is quite useful.

Through genetic modification of the genes responsible for "signal molecules" that induce changes in nerve cells, or via transplants of gengineered nerve tissue to the notochord (the embryonic spine), it may be possible to activate neural gating circuits in the spinal cord to deliberately mitigate incoming pain signals before they are perceived, without destroying the ability to sense pain as a whole. Of course, the opposite could be done to *enhance* the ability to feel pain . . .

Revised Pain Thresholds

Name	Cost	Page	TL
High Pain Threshold	10	B20	9
Low Pain Threshold	-10	B29	9

Sexual and Reproductive Modifications

"Jace, it's a hot scoop – the Wimmin's Pantropic Collective are having another try at colonizing Sappho IV, and you should see what they're building into their daughters' germ plasm. Sal got an insect bug into their birthlab. Book both Morgana Selene and one of those Neo-Christian cybervangelists on tonight's show. We'll ambush 'em with the vid and watch the fur fly."

– Noriko Hayakawa, host of *Cyberia Beat*

These advantages have minimal impact on adventures, but may have a dramatic effect of the way a particular society functions!

Altered Sex Ratio modifies the ratio of male to female births. This can be a specific ratio (e.g., five women to every man) or even eliminate births of either sex. This is a 0-point feature.

Camazotz-Series Parahuman (TL10)

ST -2 (-15 points), DX +1 (10 points).

Racial Advantages: Acute Hearing +2 (4 points), Acute Taste and Smell +1 (2 points), Claws (15 points), Flight (Winged, -25%; Requires Low Gravity: 0.3 G, -35%; Nuisance Effect: No Fine Manipulators, -30%; 10 points), Fur (4 points), Sharp Teeth (5 points), Sonar Vision (25 points), 3D Spatial Sense (10 points), Ultrahearing (5 points).

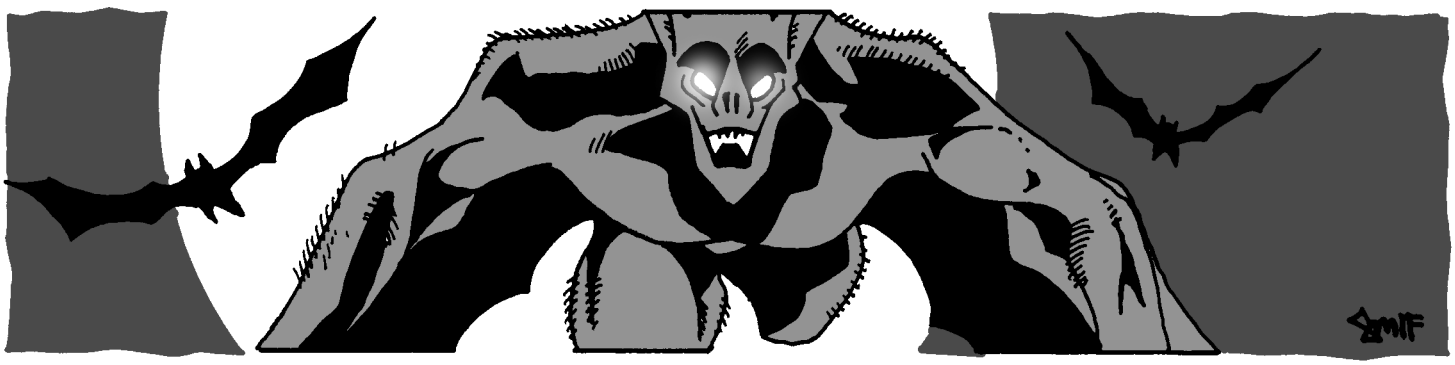
Racial Disadvantages: Fragile (-20 points), Skinny (-5 points), Unusual Biochemistry (-5 points).

Features: Due to their hollow bones and slight build, weight is 50% of the norm for their height.

Racial Cost: 45 points.

Camazotz-series parahumans have a sizable percentage of bat genes spliced into their genome. Their arms double as wings, although they can't be used as arms when they're flying. They possess large, pointed, bat-like ears, fangs, and soft fur, as well as a modified voice box with natural sonar abilities. Aside from serving as a night-vision aid, this has security (peering inside packages) and medical (performing sonograms) uses.

This is the racial template used to create Tizbeth and her siblings (see p. 26). They were designed as explorers and rangers for an exotic world (a rare planet with low gravity but thick, breathable atmosphere), where their flight and sonar (to see through thick fogs) were invaluable. However, a bat parahuman could be grown as an unusual toy or courtesan, or intended for work in a microgravity habitat like a hollow asteroid or domed lunar city.



Chronos-Series Bioroid (TL10)

ST +2 (20 points), DX +1 (10 points), IQ -1 (-10 points), HT +1 (10 points).

Racial Advantages: Acute Hearing +2 (4 points), Cast Iron Stomach (15 points), Combat Reflexes (15 points), Discriminatory Smell (15 points), Fur (4 points), Hyper-Reflexes (15 points), Sharp Teeth (5 points), Single-Minded (5 points), Very Rapid Healing (15 points).

Racial Disadvantages: Bloodlust (-10 points), Disturbing Voice (animal-like, -10 points), Low Empathy (-15 points), Self-Destruct (-20 points), Short Lifespan 2 (-20 points), Sterile (-3 points), Unusual Biochemistry (-5 points).

Racial Cost: 40 points.

Designed for unsupported, long-range patrol and counterinsurgency operations, Chronos-series combat bioroids are lean and muscular, with canine muzzles and sharp teeth, but large mouse-like ears and eyes. Their bodies are covered with short grey fur. They are transgenic hybrids of human, canine, rodent and shark genes. They possess modified stomachs so they can live off the land, and bone marrow and adrenal gland upgrades to improve emergency response and health.

Optimized for tracking and spotting the enemy, and rapid reaction to ambushes by shifting into biological overdrive, the Chronos series bioroids are most often deployed in small teams to range ahead of human troops and conduct recon, guerrilla-hunting and strike operations.

Light Menses may be achieved through alterations to female ovulation and hormone function so that post-pubescent women experience greatly reduced monthly discomfort due to PMS and menstruation, as well as the later problems of menopause. This may result in either a very mild period or, if taken in conjunction with either Sterile (p. CI84, -3 points) or Reproductive Control (below), no menstruation at all.

Estrus is another approach to avoiding menstruation, altering humans to become fertile for one month of the year (much like cats or dogs). This is worth 0 points, since the advantages and disadvantages cancel out. Males can also have a version of this. Variant humans (male or female) with this feature often have Lecherousness, only in mating season (-75%) for -4 points.

Reproductive Control is also possible, allowing females to control their fertility. This will usually require a day or so to adjust hormonal levels. Combined with the Light Menses modification, this means a woman has a period only if she voluntarily chooses fertility in a particular month. Alternatively, and for the same point cost, a female could be able to absorb an early fetus back into the womb, like a rabbit, with pregnancy being cancelled on a successful Will roll.

Sexual Orientation can perhaps be selected – some credible theories suggest a tendency toward heterosexuality, bisexuality or homosexuality may be partially or even largely predetermined by genetic inheritance. If so, gengineers should be able to select sexual preference before birth, a procedure with potentially explosive social consequences. Predetermined sexual orientation is a 0-point feature, not an actual advantage or disadvantage.

Shorter Gestation: It may be possible to reduce the length of the human gestation period, perhaps by modifying human growth factors or altering the chemical environment in the womb. Each level of this advantage reduces the gestation period by 1/6 its original length (-1.5 months in a human), to a maximum of 3 levels. This is convenient for the mother, as well as allowing faster population growth – but careful gengineering will be needed to ensure that the fetus develops normally.

Easy Childbirth: Modifications to the structure of the pelvis to help mothers deal with the delivery of (large-headed) human babies have been an ongoing part of human evolution; further ergonomic improvements may be possible via genetic engineering. The ability to shut down many (but not all) pain receptors during delivery may also be welcomed by many women. This advantage gives a +2 to HT rolls to determine the success of any pregnancy.

Extended Fertility: As lifespans increase, genetic engineering may be used to extend the period in which both sexes can produce children. With this advantage, fertility is retained until the third aging threshold (e.g., 90 in a normal human).

Increased Fecundity: This modification means that a woman is more likely to experience multiple births; releasing two eggs every ovulation, for example, could result in twins in as many as one-quarter of all pregnancies. It is a good idea to combine this with the Easy Childbirth advantage!

Hermaphroditism occurs naturally in some humans, but usually the mutation is vestigial, and not noticed until puberty. At TL10+, genetic enhancement might create functional "hermaphromorphs," able to switch sexes or be both at once, which a tolerant culture might find interesting. A "utopian" society might try to give everyone this ability to ensure sexual equality (no sexual discrimination if everyone is both sexes).

Parthenogenesis in females may be possible through very high-tech gengineering of the human ovum and reproductive organs. A woman's egg cells would carry a complete chromosome map, and could be diverted to her womb, then brought to term. Pregnancy would be triggered by voluntary hormonal changes learned through biofeedback, or by taking a pill ($2). The fetus would effectively be her clone. Parthenogenesis is a superior strategy for rapidly increasing a race's numbers, and might be deemed viable for an all-female sub-race. It means the race won't change, but if they have the capability to gengineer themselves, then natural evolution is probably no longer something to worry about.

Exotic Genitalia: May include "improved" shape or texture, extra organs in the same or new places, or erectile tissue added to other areas, such as lips or fingertips.

Sexual and Reproductive Modifications

Name	Cost	Page	TL
Altered Sex Ratio	0	–	9
Estrus	0	–	9
Extended Fertility	0	–	9
Increased Fecundity	0	–	9
Light or No Menses	1	–	9
Reproductive Control	2	–	9
Sexual Orientation	0	–	9
Shorter Gestation 1-3	1/level	–	9/10/11
Easy Childbirth	1	–	10
Hermaphromorph	2	CI57	10
Parthenogenesis	0	–	11
Exotic Genitalia	1 or 3*	49	9

*3-point version adds racial +1 to Erotic Art skill (p. CI159)

Transformations

Today, Kosmozavot Tenno Tanjo's gengineers announced success on their Void-Dancer project. They've added a vacuum-adaptive skin, special muscle sphincters that seal guts and lungs, and nictating membranes for the eyes. The Void-Dancer parahumans are supposed to survive in space without protective gear for an hour or more. According to KTT, the productivity and cost savings from being able to avoid suit-up/suit-down time, safety checks and suit training alone will pay for the program.
– Chance Mackintosh, *Posthuman Consumer Review*

At very high TLs, highly unusual changes are possible, probably using completely synthetic DNA sequences. Elastic Skin or Vacuum Adaptation, for instance, require the creation of new voluntary muscles (to change shape in one case, to close off openings in the other) and the extensive bioengineering of skin cells and, in the case of Vacuum Adaptation, internal organs.

This kind of modification may be more realistically achieved with exotic nanotech than gengineering, in conjunction with numerous limitations – for examples, see *Sample Metamorphosis Transformations* (p. 81) in Chapter 3.

Transformations

Name	Cost	Page	TL
Elastic Skin	20	CI53	11
Vacuum Adaptation	27	CI69	11
Doesn't Breathe	20	CI53	12
Doesn't Eat or Drink	10	CI53	12
Flexibility	15	CI56	12
Morph	40	CI61	13
Vacuum Support	40	CI70	13

Xeno-Anatomy

These are traits that humans don't possess at all, such as claws or fur. They are borrowed from terrestrial animals by direct transgenic gene splicing, or more commonly, by creating synthetic genes copied from or patterned on other species:

Amphibious represents gengineering for webbed fingers and toes, and is often associated with a sleek coat of fur like a seal, or very light scales.

Bioelectric Organ is an exotic modification that uses modified plates formed from muscle tissue, derived from electric eel genes. This may give Bioelectric Shock (p. CI50), Shock or Surge (p. CI73). The latter two should have

Gilgamesh-Series Parahuman (TL10)

DX +1 (10 points), IQ +1 (10 points), HT +1 (10 points).

Racial Advantages: Attractive (5 points), Extended Lifespan 1 (5 points), Immunity to Disease (10 points), Longevity (5 points), Sanitized Metabolism (5 points).

Features: Taboo Traits (Genetic Defects, Mental Instability).

Racial Cost: 60 points.

Gilgamesh-series parahumans are a *Homo superior* design intended for high intelligence and lengthened lifespan. The Gilgamesh series looks human, but features extensive eugenic and species modifications, including redesigned heart, arteries, spleen and gastrointestinal tract, plus alterations to the cell structure itself to reduce cumulative copying errors.

Costs Fatigue (p. CI110) or Limited Uses (p. CI111). Lightning (p. CI73) would require more energy than a human body could store; it's only possible if magic, psi or super powers can be gengineered.

Clinging represents tree-frog or insect-type suckers on hands and feet.

Flesh Pockets are natural pouches, like those of marsupials, which may be useful for carrying tools or concealing weapons, as well as holding babies.

Fur, Scales and other exotic body coverings are usually intended for aesthetic effect. Some serve more practical purposes, such as protecting colonists designed for harsh climates. Many are side effects of blending human and animal genes in search of other advantages like xenosenses.

Nictating Membranes, like a reptile's, protect the eyes. This modification may be common in pantropic parahumans designed for worlds with irritant atmospheres or perpetual dust storms.

Xeno-Anatomy

Name	Cost	Page	TL
Amphibious	10	CI49	9
Flesh Pockets	varies	136	9
Temperature Tolerance 1-9	1/level	CI30	9
Nictating Membrane	10/level	CI62	10
Temperature Tolerance 10+	1/level	CI30	*
Clinging	25	CI51	11**
Xeno-Skin:			
Fur:			
very thin	0	CI56	9
regular	4	CI56	9
thick	29	CI56	9
spiny	33	CI56	10
Scales			
very light	0	CI57	10
regular	3	CI57	11
heavy	28	CI57	11
Thick Hide	28	CI57	10
Armor Plates	59	CI57	11
Carapace	56	CI57	12
Chameleon	7/level	CI51	12
Strikers:			
Butting Horns	5	CI67	9
Claws or Sharp Claws	15/25	CI67	9
Sharp Teeth or Fangs	5/10	CI67	9
Spear	30	CI67	9
Spines	5	CI67	10
Long Tusks	50	CI67	10
Talons or Long Talons	40/55	CI67	10
New Organs:			
Bioelectric Shock	10	CI50	11
Shock	20	CI73	11
Surge	15	CI73	11

* Equal to level, e.g., level 12 requires TL12.

** Clinging often has the Requires Low Gravity limitation (p. 138). If it requires 0.5 G, it's only TL11, while if it requires 0.2 G or less, it's only TL10.

Xenoglands

"Today's featured company expose is Onokage Labs. This shadowy Kyoto-based corporation has carved out a niche for itself in custom gengineering for the rich and decadent of Asia-Transpacific. Their living products are well known among connoisseurs of the bizarre – and not always what they seem. Take their Fugu-series plea-

sure bioroid: an exotic beauty with lavender skin and white hair, she also possesses genemod venom sacs and sharp fangs capable of delivering endorphins. Her 'love bites' can make you high, but too much of a good thing can kill you."

– Noriko Hayakawa, host of *Cyberia Beat*

The most common *exocrine glands* derived from non-human species are venom sacs based on those of reptiles or amphibians – usually in conjunction with Sharp Teeth or Claws (above). Gengineering of these, or of modified hormone glands, may permit chemicals produced in the body (including exotic, new ones) to be secreted externally. At high TLs, glands (such as spinnerets) capable of secreting enzymes and proteins derived from insect or arachnid genes may allow clinging or web-slinging. Other exotic possibilities are enhanced sweat glands to provide Temperature Tolerance, or squid-like ink glands giving the Smoke advantage (with the -30% limitation "only useful in water").

Xenoglands

Name	Cost	Page	TL
Drug Factory	20+10/extra drug	CI53	*
Temperature Tolerance	1/level	CI30	10**
Venom	15/level	CI71	10**
if corrosive	15/level	CI71	11**
Smoke (as ink)	11	CI73	11
Clinging	25	CI51	12
Webbing	20+2/ST	CI71	12**

* More commonly used in animals than humans – see *Pharm Animal Modifications* on p. 98 for detailed rules.

** +1 TL for every full five levels of this advantage.

Limitations: The Limited Uses limitation (p. CI111) is very common for all types of xenoglands. Clinging often has the Requires Low Gravity (p. 138) limitation; if it requires 0.5 G, it's only TL11, while if it requires 0.2 G or less, it's only TL10.

Gengineered Disadvantages

Most gengineered sub-races should have some disadvantages. This has the dual benefit of reducing their racial point cost and making them more realistic. Disadvantages fall into two categories: *intended defects* and *unintended defects.* The former are chosen by the gengineer to suit his or his employer's purposes. The latter usually result from a specific desirable trait being linked to an unwanted gene sequence, with the disadvantage being overlooked, or tolerated in this particular design, because it was too much trouble to gengineer it away.

Pandora-Series Parahuman (TL10)

IQ +2 (20 points), HT -1 (-10 points).

Racial Advantages: Enhanced Time Sense (45 points).

Racial Disadvantages: Overconfidence (-10 points), Stuttering (super-rapid speech, no penalty if talking to someone else with Enhanced Time Sense, -10%, -9 points).

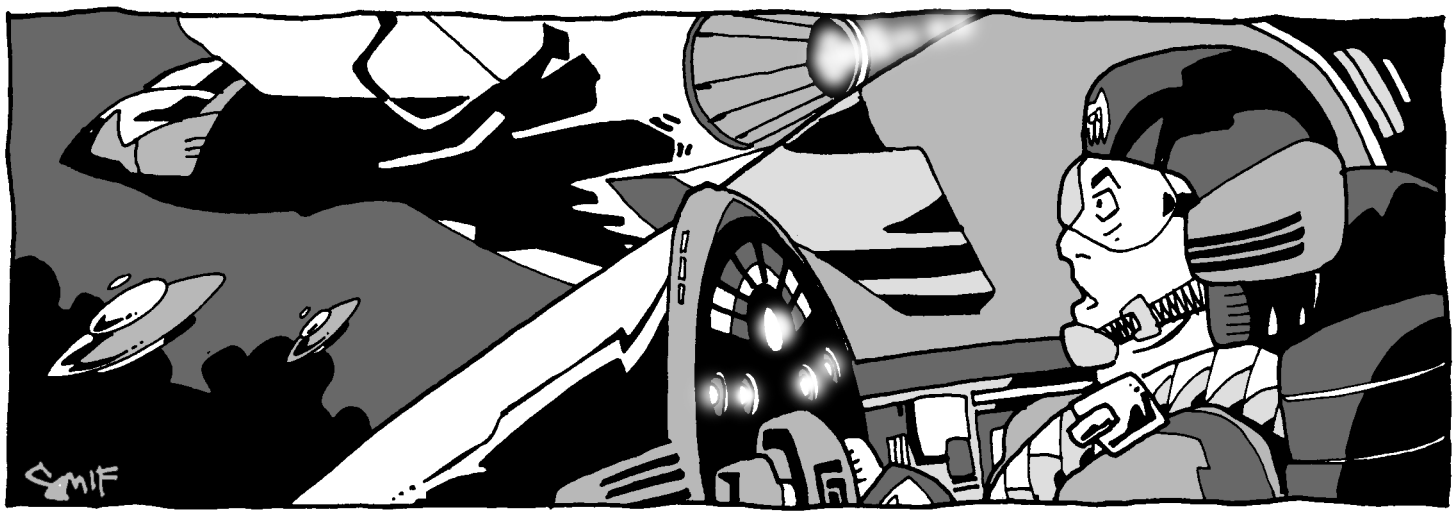
Features: Taboo Traits (Genetic defects).

Racial Cost: 36 points.

Instead of just gengineering a smarter human, the goal of the Pandora's designers was to create a faster-thinking one. The resulting Pandora-series genetic upgrades look identical to normal humans, but their brains have been neurologically modified to improve information flow between neurons, permitting faster thought.

Unfortunately, the interface with the speech centers of the brain was not as smooth as intended: they don't actually stutter, but they do find it hard to slow their words down when talking to normal people, so the effect is about the same. The Pandoras were also not as robust as Matsai had hoped.

Despite their flaws, the Pandoras are popular, general-purpose *"Homo superior"* genetic upgrades, likely to find jobs in many different fields, especially where complex snap decisions are required, such as surgery, piloting or even battle management.



Mental Disadvantages

We must ensure that the bioroids we create are happy in their jobs. A happy worker is a productive worker. We can point to the success of the Eros-5's hormonal imbalance: To be crude, the E-5's are always in heat, hence eager to please.

– Internal memo, Biotech Euphrates

Intended Defects: What might be a disadvantage to the individual can suit the purposes of the gengineer. It's possible to deliberately eugeneer a careful imbalance of neurotransmitters and glandular hormones to result in a predisposition toward certain distinct mental states, such as aggressiveness or lecherousness. Sometimes, the goal is a more tractable variant race: a slave with Combat Paralysis will be less likely to rebel, and one with Dyslexia won't get dangerous new ideas through reading. Other changes may be intended to suit a person to his job, for example, instilling Lecherousness in a pleasure model or Bloodlust in a soldier.

By tinkering with the genes that regulate behavior-modifying neurotransmitters, like MAO inhibitors, an unspecified *mental instability* can be engineered. This is usually intended as a form of genetic booby trap; e.g., someone orders or awakens a clone, but a saboteur has secretly gene-modified it to go crazy after it awakes. In game terms, the template is not given specific mental disadvantages to represent this, but simply 20+ points of unspecified mental disadvantages. These differ from individual to individual, and are chosen by the GM, usually from among Chronic Depression (p. CI87), Delusions (p. B32), Edgy (p. CI90), Manic-Depressive (p. CI92), On the Edge (p. CI93) or Paranoia (p. B35).

Unintended Defects: Increasing intelligence or adding glandular or neurological modifications may have unintended psychological consequences, reflected by various disadvantages. Parahumans with animal DNA may even occasionally revert to more primitive behaviour patterns (Stress Atavism). Use the same list as for intentional disadvantages, plus the "Mental Instability" problems described above.

In particular, someone with performance-enhancing glandular modifications like Combat Reflexes, Hyper-Reflexes, Hyper-Strength or Increased Speed may suffer from mental disadvantages that trigger *after* a stressful situation is over. Post-Combat Shakes (p. CI93) is common, as are disadvantages like Gluttony, Lecherousness or Stuttering with the limitation Post-Emergencies Only (-50%, p. 138). In this case, the hormones produced by combat overdrive causes a glandular imbalance that results in temporary aberrant behavior for several minutes afterward.

Spartan-Series Bioroid (TL10)

ST +5 (60 points), HT +1 (10 points).

Racial Advantages: Combat Reflexes (15 points), Extra Encumbrance (5 points), High Pain Threshold (10 points).

Racial Disadvantages: Self-Destruct (-20 points), Short Lifespan 1 (-10 points), Sterile (-3 points), Unattractive (-5 points).

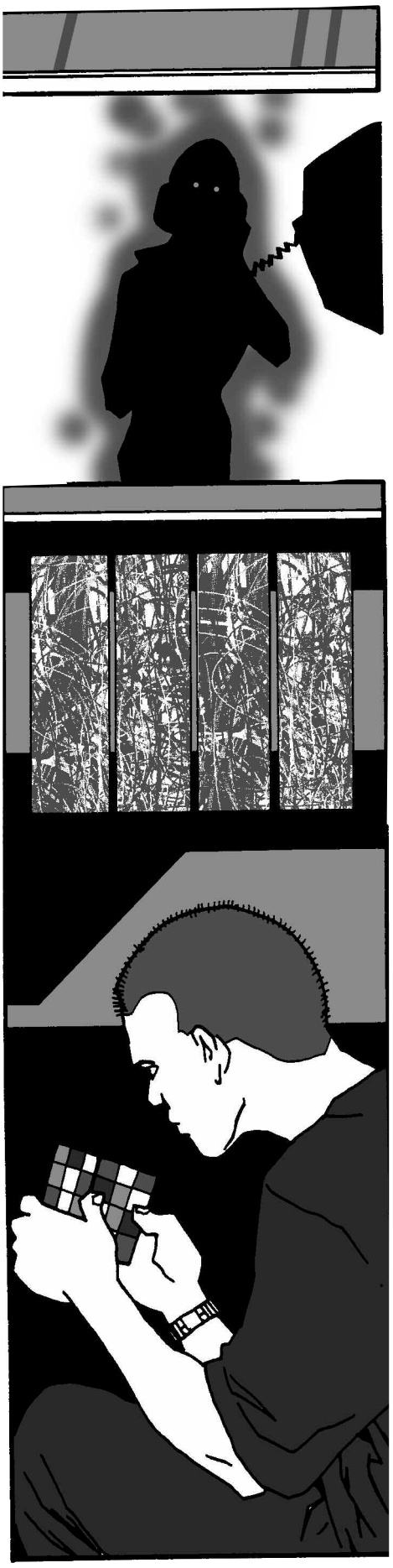
Racial Cost: 62 points.

This is a typical high-end bioroid soldier: hormone-boosted muscle growth, skeletal strengthening, revised pain threshold and endocrine system adjusted for improved stress response. While high strength in and of itself is of limited use in ultra-tech combat, the objective was to grow a trooper who could use heavy infantry weapons without a two-man team, bionics or a battlesuit.

Mental Disadvantages

Disadvantage	Cost	Page	TL*
Absent-Mindedness	-15	B30	9
Attentive	-1	CI86	9
Bad Temper	-10	B31	9
Berserk	-15	B31	9
Bloodlust	-10	B31	9
Bully	-10	B31	9
Callous	-6	CI86	9
Cannot Learn	-30	CI86	9
Chronic Depression	-15 + -2/level	CI87	9
Combat Paralysis	-15	B32	9
Confused	-10	CI88	9
Cowardice	-10	B32	9
Distractible	-1	CI89	9
Dreamer	-1	CI89	9
Dyslexia	-15	B33	9
Gluttony	-5	B33	9
Hidebound	-5	CI91	9
Impulsiveness	-10	B33	9
Laziness	-10	B34	9
Lecherousness	-15	B34	9
Low Empathy	-15	CI91	9
Megalomania	-10	B34	9
Overconfidence	-10	B34	9
Paranoia	-10	B35	9
Shyness	-5 to -15	B37	9
Slave Mentality	-40	CI94	9
Split Personality	-10/-15	B37	9
Stress Atavism	-16	CI105	9
Stubbornness	-5	B37	9
Stuttering	-10	B29	9
Weak Will	-8/level	B37	9
Workaholic	-5	CI95	9
Curious	-5 to -15	CI89	10
Incurious	-5	CI91	10
Indecisive	-10	CI91	10
Selfless	-10	CI94	10

* TL only applies if the disadvantage is an *intended* defect.



Physical Disadvantages

Intended Defects: Some variant races are eugeneered with deliberate physical defects. For example, a wealthy sadist might want his latest concubine to be an albino with Low Pain Threshold, while the eccentric Sultana of Gideon Prime might desire her bodyguard of gene-enhanced janissaries to have both Gigantism and Mute. The most commonly engineered physical disadvantages chosen for aesthetic effect are Albinism, Dwarfism, Eunuch, Fat, Gigantism, Light Sleeper, Low Pain Threshold, Mute, Overweight, Skinny and Sterile.

Self-Destruct and Short Lifespan are also common in slave races, produced through modifications to the endocrine system or built in "suicide clocks" in cells. Usually, the goal is to ensure demand for new product via planned obsolescence. Short Lifespan might also be popular for non-sterile slave races, as it allows faster reproduction; in bioengineered humans that aren't property, the advantage Early Maturation would be used instead.

Unintended Defects: IQ or HT penalties, Delicate Metabolism, Low Pain Threshold, Sterile, Unusual Biochemistry and Weak Immune System are the most

common defects produced when designers get too ambitious. In particular, Unusual Biochemistry is almost certain to occur when attempting complex, transgenic gene-splices, chimeras and cell fusions. Other modifications may be side effects of trying for a specific advantage or mixing human and non-human genes. For instance, Fragile (representing light, hollow bones like a bird's) might be a side effect of designing a winged human.

Unless intended, or inextricably linked to some far more important and rare trait, the grosser physical disadvantages like Blindness, Hemophilia or One Arm are unlikely in a variant race, as defects this obvious will usually be detected in the womb and either corrected via genetic surgery or result in termination. The most common "tolerated" physical disadvantages are listed on the table below; they are all TL9.

Virtually any other physical disadvantage from ***GURPS Basic Set*** or ***Compendium I*** is also possible.

Physical Disadvantages

Disadvantage	Cost	Page
Albinism	-10	B27
Appearance	varies	B15
Bad Sight	-10/-25	B27
Color Blindness	-10	B28
Deafness	-20	B28
Delicate Metabolism	-20/-40	CI81
Disturbing Voice	-10	CI81
Dwarfism	-15	B28
Epilepsy	-30	B28
Eunuch	-5	B28
Extra Sleep	-3/level	CI81
Fat	-10/20	B28
Gigantism	-10	B28
Gluttony	-5	B33
Hard of Hearing	-10	B28
Light Sleeper	-5	CI82
Low Pain Threshold	-10	B29
Migraine	-5 to -20	CI82
Mute	-25	B29
Overweight	-5	B29
Reduced Hit Points	-5/level	CI83
Skinny	-5	B29
Sterile	-3	CI84
Unnatural Feature*	-5	CI85
Weak Immune System	-30	CI85
Species Modification		
Aquatic	-40	CI101
Fragile	-20	CI102
Reduced Move	-5/point	CI103
Self-Destruct	-20	CI104
Short Lifespan	-10/level	CI104
Sleepy	varies	CI104
Slow Healing	-5/level	CI104
Unusual Biochemistry	-5	CI106

* Remember, this only qualifies if the feature is somewhat disturbing *and the variant race is otherwise human-like.*

Other Features

Besides specific modifications or defects, a race may also have a variety of secondary, 0-point features. Several such features appear under *Gengineered Advantages* (p. 51ff). One special class of features, *taboo traits,* merits additional discussion.

Taboo Traits

Some genetic constructs undergo selection to screen out or mitigate undesirable traits; therefore, certain advantages or disadvantages may be forbidden to individual characters built with such racial templates. A forbidden advantage or disadvantage is called a *taboo trait* (p. CI176). It costs no character points to assign a taboo trait to a racial template – it's a 0-point feature.

For instance, a character can normally have Berserk as a personal disadvantage, even if it isn't in his genetic template. However, if Berserk is a taboo trait for his template, then it cannot be taken.

Taboo traits that cover a general class of disadvantages do not prevent *specific* disadvantages from within that class from being part of the racial template. The prohibition is also lifted for disadvantages that are acquired after birth (e.g., due to a proteus virus or brainwashing).

One way to add a taboo trait to a template is through *genefixing.*

Genefixing

"Unlike a lot of cults, the Neo-Gnostics don't have a taboo against genefixing. Or maybe they just considered it the lesser of two evils when they hired me to ensure none of their babies would ever be born with a lecherous gene in his or her body."

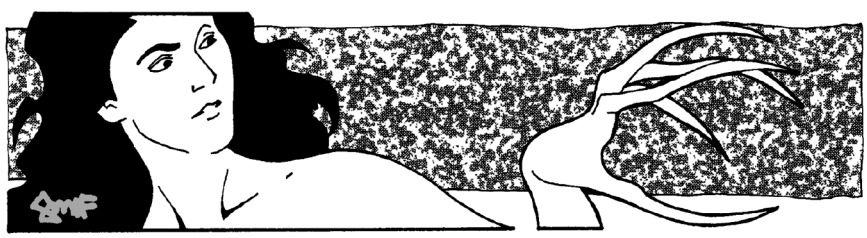
– Dr. Lucien Locke, Genehackers Inc.

The practice of "genefixing" consists of testing germ plasm for genetic defects, such as hereditary diseases, and then fixing them through gengineering at conception. This is the easiest type of trait selection for society to accept – making sure that genes for good physical or mental health are coded into children, while defects are fixed.

At TL8, this is limited to major genetic defects, where genetic errors result in an excess or deficiency of certain proteins or hormones, producing problems like Dwarfism or Hemophilia.

At TL9+, the definition of "defect" can be extended, ensuring that minor flaws like lantern jaw, knock knees, snaggle teeth, excessive acne and so on are not in a genotype.

It should be possible to suppress or edit gene sequences connected with a tendency toward certain mental states, such as rage, lecherousness or poor self-control. It's not possible to genefix specific



Tek Rat
Parahuman (TL10)

ST -5 (-40 points), DX +1 (10 points), IQ -1 (-10 points).

Racial Advantages: Acute Hearing +1 (2 points), Acute Taste and Smell +1 (2 points), Decreased Life Support (2/5 food consumption, 10 points), Extra Arm (no physical attack, 5 points), Flesh Pocket (2 points), Fur (4 points), Sharp Teeth (5 points), 3D Spatial Sense (10 points).

Racial Disadvantages: Gluttony (-5 points), Reduced Hit Points -5 (-25 points).

Features: Miniature (2/5-scale). After calculating height and weight based on ST, multiply height by 2/5 and weight by 1/16. Normally has 6 meals a day, but each is only 1/16 as large as a human meal.

Racial Cost: -30 points.

Fourth Officer Ratzelle is just over two feet tall, has short brown fur, and lives in the vacc-suit locker. Her coverall is always covered in grease, her voice is an irritating chitter, and when she's not working, she's stuffing her face with junk food. But who's complaining? Hiring her was the first smart move the captain pulled since he spaced the S-3 unit. Now our hyperdrive works all the time, the nanotoaster's no longer a menace and she even squirmed up the Milliken Tube to hose the scorpio wasps out of number-two engine. Every ship should have a Tek Rat.

Using a mix of human, raccoon and possum genes, the Tek Rat is about 2' to 2.5' tall, with a rodent-like face, miniature prehensile tail and marsupial pouch it uses for young or tools. It has undergone TL10 eugenic modification for a higher IQ and ST to counteract its small size, and its cardiovascular system is also somewhat more efficient (giving an extra hit point).

Void-Dancer-Series Parahuman (TL11)

ST -3 (-20 points), HT -1 (-10 points).

Racial Advantages: Longevity (5 points), Oxygen Storage (14 points), Prehensile Toes (see p. 39, 7 points), Pressure Support (100 atm, 10 points), Sanitized Metabolism (5 points), Slow Regeneration (only to replace bone decalcification, -75%, 3 points), 3D Spatial Sense (10 points), Toughness 1 (10 points), Vacuum Adaptation (27 points).

Racial Disadvantages: G-Intolerance (0.05G increment, -20, Skinny (-5 points), Weak Immune System (-30 points).

Racial Cost: 6 points.

Designed as zero-G construction workers, space crew and belt miners, the slender Void-Dancers have been extensively adapted to the space environment. Radical dermal and internal modifications (see *Transformations,* p. 49) modify them to survive pressure changes and hard vacuum, and they can function without air by storing an hour's worth of oxygen in a modified liver. Brain and inner ear modifications adapt the Void-Dancers for life without verticals, while cardiovascular and glandular tinkering optimize the metabolism for low or no gravity (and incidentally extend lifespan). Dexterous prehensile toes on the feet effectively give them a useful pair of additional arms when not walking on them; i.e., in zero-G.

Unfortunately, the gengineers' goals outstripped their capabilities, leading to genetic defects that left this particular model with no resistance to most terrestrial bacteria. In sterile, zero-G habitats, among other Void-Dancers or sanitized humans like the Gilgamesh-series, this isn't a problem – but it restricts their ability to interact with normal humans.

mental disorders, such as an individual obsession or phobia, but manipulation of genes governing behavior-modifying neurotransmitters (such as serotonin) can deliberately create "stable personality" genotypes that are less likely to suffer from some forms of mental illness. This is the reverse of the technique used to create the "genetic booby traps," described under *Mental Disadvantages* (p. 52).

While genetic behavioral modification of this sort may be controversial, eliminating aggressive or unstable mental traits may seem more benign. However, it can have an interesting effect on a culture over the long term. A non-aggressive culture might be in trouble the next time it runs into an external enemy, and who knows how many famous prophets, messiahs and political leaders might have gained their inspiration from mild mental disorders?

Some possible genefixed taboo traits are:

Taboo Trait: Genetic Defects (TL8): Prohibits taking attributes more than 2 below whatever the genetic template's average is (adjusted by age). Also prohibits the disadvantages Albinism, Bad Sight, Color Blindness, Dwarfism, Dyslexia, Gigantism, Hemophilia, Innumerate, Night Blindness, No Sense of Smell/Taste, Non-Iconographic, Short Attention Span, Tourette's Syndrome and Weak Immune System.

Taboo Trait: Unattractiveness (TL8): Prohibits an Appearance of Unattractive or worse, Bad Smell, Fat, Overweight and Very Unfit.

Taboo Trait: Aggressiveness (TL9): Manipulation of genes governing certain hormone-producing glands may create a non-aggressive genotype which prohibits Bad Temper, Berserk, Bully and Stubbornness.

Taboo Trait: Mental Instability (TL9): Prohibits Chronic Depression, Delusions, Edgy, Extreme Fanaticism, Fanaticism, Flashbacks, Guilt Complex, Kleptomania, Lover's Distraction, Low Self-Image, Lunacy, Manic-Depressive, Megalomania, Obsession, On the Edge, Paranoia, Pyromania, Voices and any Phobia worth -10 points or more.

Individual disadvantages which could be taboo traits are Lecherousness (TL9), Shyness (TL9) and Laziness (TL10). It's impossible to gengineer against (or for) more complex disorders, such as specific Obsessions or Phobias.

Racial Point Cost

This is the point cost required to play someone with a particular variant human template. It is the sum of the costs of all attribute modifiers, advantages and disadvantages. If necessary, the GM can balance designs by adding unintended disadvantages.

The GM should try to keep the point costs of races intended for use by PCs below the average point total of the campaign, and usually no more than half that cost. Thus, in a game with 100-point characters, races costing more than 100 points should be avoided, and most should cost 50 points or less. On the other hand, in games with very high point totals – such as ***Black Ops, Special Ops*** or ***Supers*** – having "super races" with very high point totals is perfectly in genre.

These are simply play-balance guidelines, not a hard-and-fast rules; GMs can ignore them or modify them as he sees fit.

Life's Price Tag

If someone purchases a set of genetic modifications, how much does it cost? This depends on how complex the nucleotide sequences used in the genotype were, and whether the buyer is ordering a custom-designed genotype or a tried-and-true one.

Established Variant Races

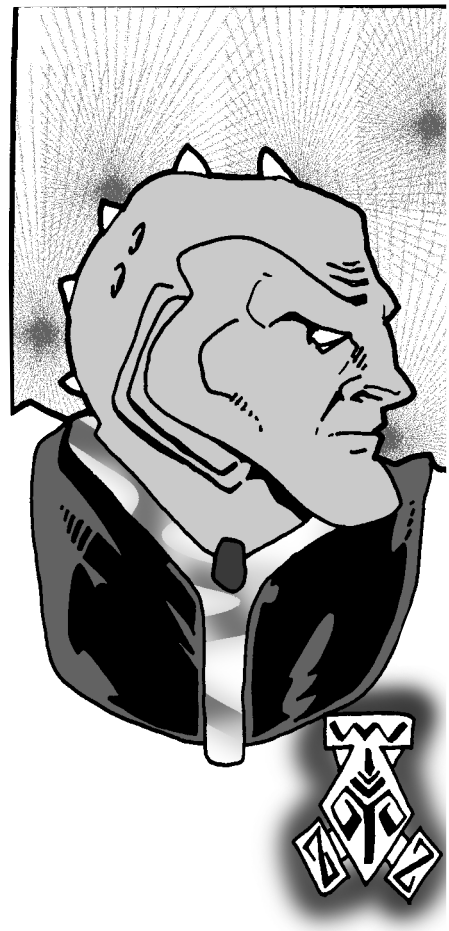
Once one example of a variant race has been created, that same genetic sequence can be used to modify other human reproductive cells. Since the complex research and development has already been done, it may be possible to simply go to a biotech company and purchase a "genetic program" or "genetic upgrade sequence" for one's unborn children or, if it's legal, have one grown or cloned to order. Depending on the law, a bioengineered person may be considered a child (with whatever legal rights children have) or a form of property.

Assuming it's legal, a suggested price tag for an embryo is $25,000 if only eugenic modifications were made, or $50,000 if any species modifications were performed. This *includes* purely cosmetic species modifications (gengineering someone with slit-pupil eyes, cat ears and a tail is still expensive, even if it isn't worth character points). If the racial *point* cost is positive, increase the dollar cost by $1,000 per point. If the racial point cost is negative, use only the base cost quoted above. For non-human races that start out with racial bonuses, ignore those that are "native" to the race before gengineering when calculating the price tag. (An alternative and more complex way of pricing "biological androids" is presented on p. RO81; this can be used, if desired.)

Note that this cost reflects the *utility* of the genetic modification, rather than the difficulty required to design it!

This buys a viable embryo, which can then be implanted in a surrogate mother of the same or similar species (e.g., a human could bring a parahuman to term), raised in an artificial womb, or cloned; see *Reproductive Technology* (p. 17). There may be additional costs for things like sex selection – see the sidebars.

Example: Mei and Yukio were both created from cells donated by their parents, using the Pandora-series genetic upgrade (sidebar, p. 51). This variant template costs 36 points. Since one of their advantages was a species modification, their parents paid $50,000 + $36,000 = $86,000 for the privilege of mentally-enhanced but slightly-fragile offspring. In Mei's case, her mother had the embryo implanted and carried it to term herself; Yukio was grown in a forced-growth tank. Aside from that, Mei is of average height with black hair, while Yukio is a tall redhead. They could have any mundane advantage or disadvantage not prohibited by the taboo against genetic defects.



Custom Designs

If no one has designed a particular trait before, the *germline gengineering* procedures (Chapter 1, p. 9) should be used. People can hire a genetic engineer (see the *Job Table,* p. 133) or do the job themselves.

First, human gametes (egg and sperm cells) are needed. These might be provided by the customer (one or two parents might donate their own reproductive cells for modification), or be specially selected for their eugenic characteristics.

Second, a gengineer with an appropriately-equipped lab is required. Custom gengineering *requires* a genetics lab. Hiring a genetic engineer (or a biotech company) to add new modifications to a particular human zygote is expensive.

The resulting racial template may vary somewhat from the designer's intentions – in game terms, the person ordering the gengineering specifies the desired changes, then the GM adds additional "unintended" disadvantages based on how well or poorly the gengineering was performed. Any trait not specifically gengineered (that is, specified in a racial template) will depend on the genetic parents (whoever provided the egg cell and sperm used).

Genetic Engineering and Aliens

While this chapter focuses on human genetic engineering, the guidelines given here can also be applied to humanoid aliens or, with adjustment on a case-by-case basis, to even less-human species.

Some species may actually be easier to genetically engineer in certain ways. For example, insect genes are packaged in such a way that drastic morphological alteration is relatively easy (researchers have modified insects so that eyes grow on leg joints, or antennae have been replaced with legs). GMs can simulate this by making certain categories of modifications require a lower TL for one species, or a higher TL for another.

Genetic Engineering in Play

If the GM wants to "game out" the process (e.g., a PC is the gengineer) here's a set of rules for doing so:

The first stage of this process is for the gengineer to decide what traits or changes he wants to produce in an organism, within the limits of what is possible at his TL. In game terms, this is the variant racial template that the designer *wants* to have – don't include unintended defects.

The next step is coming up with the correct genetic sequences to safely produce those modifications. This requires a roll vs. Genetics (Genetic Engineering) skill. It is made at a penalty based on how complex the GM feels the changes are. The suggested penalty depends on the quantity and TL of the traits (defined as specific attribute bonuses, advantages, disadvantage or features) that the gengineer wants to add. The modifier is based on the TL of the *trait,* not the gengineer's TL. The assumption behind this is that the more complex a specific trait is, the higher its TL will be.

The penalty *per trait* is -1 for traits up to TL9, with an *additional* -1 per TL past TL9. The GM can apply extra penalties if he thinks a trait is more complex then its TL suggests; e.g., psi powers might have double the penalty. There is no extra penalty for species modifications vs. eugenic modifications – that's already reflected in the assigned TLs.

Assume that all gengineered looks (a specific level of Appearance, plus skin, hair and eye color) are a single modification ("gengineered appearance") and that purely-cosmetic, 0-point transgenic features that can be explained as part of other advantages don't count (e.g., pointed ears may be implied by Acute Hearing, or animal-like features by Fur).

Example: We want to engineer a Gilgamesh-series parahuman (sidebar, p. 50). Checking the racial template, we see it has seven traits that require TL9 or less (DX+1, HT+1, Appearance, Longevity, Sanitized Metabolism and two sets of Taboo Traits) and three traits that are TL10 (IQ+1, Extended Lifespan and Immunity to Disease). With a penalty of -1 per TL9- trait (-7) and -2 per TL10 trait (-6), the total modifier to skill is -13.

This work is usually done on a computer, and the only additional modifiers applied to the roll are bonuses to skill for computer programs assisting in the research. Since more powerful programs can be run at higher TLs, this will counteract the increased difficulty of high-tech gengineering projects.

One skill roll is allowed per week. Success means that the gengineer is ready to proceed to the next stage. Failure means he's still working on it. Critical failure means that he has a genetic sequence that looks good, but is fatally flawed – any success or critical success on the next stage will automatically become a failure, and any failure will become a critical failure.

For the next stage, the genetic engineer must have a genetic engineering lab in which to perform the actual gene splicing. Genetic material is also required. In humans, this means the eggs and sperm, collectively called gametes. These may be taken from a donor (half might come from the genetic engineer, if he wants to work on his own genetic material). Banks of frozen germ cells may also exist. In most societies, traffic in genetic material from sentient organisms is regulated, but donors are relatively easy to locate.

A "working model" skill roll is now required to perform the actual gene splicing, which is done *in vitro* and takes about a week. The GM should make this secretly as well. Use the same modifiers applied to the first roll, except that the quality of the gengineering lab will modify the chance of success: 0 if a full lab, -2 if a standard lab, -5 if a small lab, -8 if a suitcase lab. If working with obsolete equipment (less than the TL of the changes), apply

the tech level penalties from p. B185. Add +1 for every "assistant" with either Genetics (Genetic Engineering) or Biochemistry skill 20+, to a maximum four assistants.

The GM should note how much the roll succeeded or failed by, but keep it secret. The genetic engineer now has germ cells that have been altered, but he won't know how well he's done until they are allowed to develop. For this, an incubator is needed. Bacteria can grow in test tubes or vats, plants can grow in soil or hydroponics, but in the case of a species like a human, the cells must be fertilized and, after a short time replicating in a test tube, placed in a natural or artificial womb (see *Reproductive Technology,* p. 17) where they can develop progressively into an embryo, fetus and baby. Exactly what happens depends on how successful the skill roll was; see the *Genetic Engineering Table,* below.

As his creation grows, the genetic engineer can use diagnostic sensors to monitor its development for crippling defects or deformities. If everything works out, it will be brought to term. If not, it can usually be terminated at a fairly early stage. The time required before results show up depends on how fast the species grows. The results below are tailored to humans; for non-humans, adjust proportionately.

Genetic Engineering Table

Critical success or success by 10+ . . . . perfect!
Success by 5-9 . . . . viable.
Success by 0-4 . . . . semi-viable.
Failure . . . . non-viable.
Critical failure . . . . lab accident or "frankenstein!"

Perfect: A complete success! The GM may optionally allow a critical success to produce some unexpected additional advantages. This is a common plot in many SF novels, where attempts to genetically engineer one trait also produce another linked advantage that is much more radical.

Viable: The embryo develops properly, but may have 10-20 points of unintended disadvantages. GMs may wish to select them in order to make a more "balanced" racial template. Use the suggested mental and physical disadvantages given earlier in this chapter as guidelines.

Semi-Viable: The embryo develops into a fetus, but is somewhat flawed. At TL8+, a pre-natal scan will be able to note the problems, allowing the decision to abort within 1d weeks. If carried to term, it will have various disadvantages. These should be reflected by giving the species the Sterile (-3 points) and Delicate Metabolism (-40 points) disadvantages, and any other disadvantages the GM feels appropriate (usually at least equal in point total to any advantages that were deliberately added to it). Common problems that may result are Stress Atavism, Unusual Biochemistry and Weak Immune System.

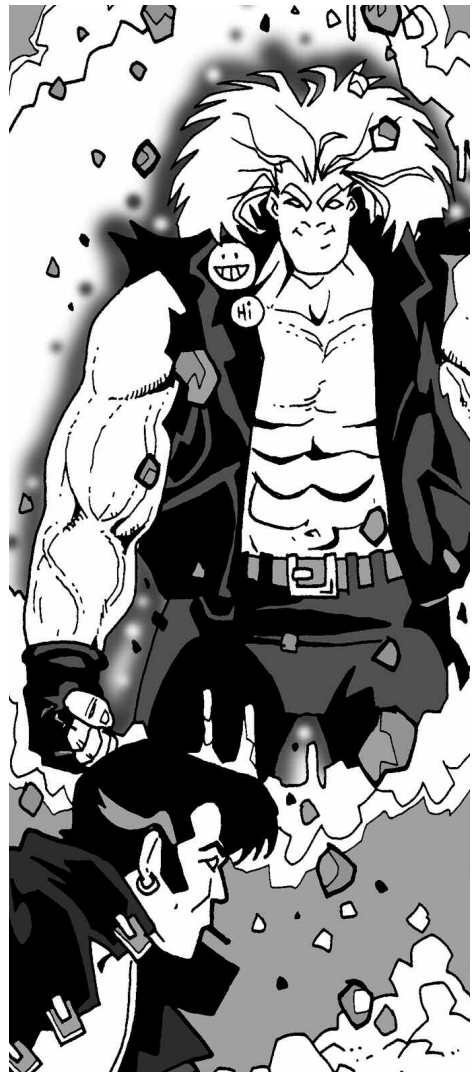
Non-Viable: The organism developed, but was too deformed to survive. On a successful Diagnosis roll, this can be noticed in 1d weeks. Otherwise, it will result in a stillbirth.

Lab Accident or "Frankenstein": Something went badly wrong. There's an equal chance of an accident or "frankenstein." A "frankenstein" means that the result *looks* good, but has some unnoticed flaw that won't become apparent until after it has been born – maybe not for *years* afterward. Perhaps it simply has some crucial genetic defect that will cut its life short soon after birth (this can be bought as Terminally Ill). Or maybe it's something more dangerous, like violent Stress Atavism that will drive it to attack its creator. Or, in a cinematic campaign, perhaps it will mutate further after its birth, maybe even turning into a killer monster! Exact details are up to the GM.

If the concept roll was a critical failure, all working models will be non-viable or worse! NPCs will usually realize their concept is flawed after 1d failed attempts (twice as many if they have Stubbornness); players may keep trying until repeated failures suggest to them that something is wrong.

Beyond the Probable

Many advantages or disadvantages aren't covered in this chapter. These are the ones that human genetic engineering would find very difficult or impossible to reproduce. This may be because they represent social relationships (like Status), experience (like Literacy), are very abstract (like Luck), or just because they would be too hard to duplicate genetically without either cybernetic implants or invoking "mutant super powers" or TL15+ "weird science." GMs may allow them to be genetically engineered if discovered in nature. For example, gengineering the ability to teleport or breathe fire is seemingly impossible – but what if a person or alien capable of it were discovered? Gengineers may try to hire or capture that individual or creature and study it. Perhaps the genes that code for this ability can be spliced into humans or other animals!



3 BIOMODS

"Okay, so the gengineers have figured out the right way to build a tougher, smarter liver that provides better resistance to toxins, or some other little upgrade to the human genome. Fine, that's great, insert the genes for it in the next generation and raise some enhanced superbrats. But that doesn't do squat for the current generation of people."

"No way! I got loads of cash, but my parents didn't have the valuta to have my genes twanked. Heck, they couldn't do that then. You telling me I'm obsolete because I'm already born?"

Stay frosty. We haven't even *mentioned* gene implants, biomod transplants, surgery and metamorphosis nanovirus. (Unless noted, the dollar cost of a biomod is halved one TL after that biomod first appears, and halved again after two or more TLs. GMs should feel free to create new biomods or alter existing ones!)

Elective Surgery

"The Rabid stepped out of the shadows. His slit-pupiled eyes were feline transplants, and as he grinned, he showed me a mouth full of canine tooth bud implants. I was impressed: The gangs must be doing well here, to afford all that surgery."
– Detective Cody Chase, Nevada PD.

Elective surgery involves reshaping, modifying or transplanting tissue, bone, organs and limbs. In some cases, it may also involve neurosurgery to ensure that certain transplants, such as limbs, function properly. Each surgical procedure ("biomod") is described with these characteristics:

Statistics: The game effects and character point cost of each surgical procedure – for instance, what advantages it grants or removes.

Operation: The cost to hire a surgeon (or medical team), along with the time required to recuperate following the operation. This period is measured in weeks. For every TL over the minimum required, reduce this by one day per week. Thus, if 6 weeks were required at TL8, this would be reduced by 6 days at TL9, by 12 days at TL10, and so on. Some operations require less than a full week to recover from. If so, reduce the period by three hours per TL over the minimum.

The recovery period required is also a rough guide to how long the operation itself takes: assume about two hours for every week of recovery required (before modification by TL). Any operation requiring less than a week of recovery takes an hour to perform.

Both recovery and operation time from multiple operations is consecutive rather than concurrent; e.g., two procedures with 2-week recovery times require 8 hours of surgery and 4 weeks of recovery.

Surgery Skill Rolls

The GM can assume that commercial hospitals are well enough trained and equipped that no skill rolls are required to perform surgery. If characters do their own work, or a back-alley surgeon is hired, use the Surgery rules on p. B56, but *instead* of the modifier listed there, assume the roll is at -1 for every week of *recovery* required (if less than a week, no penalty).

A success means the surgery was performed properly. A critical success halves the recovery time. A failure means the biomodification failed; a later attempt is possible after the patient recovers (full recovery time still applies). Failure *also* inflicts 1d damage for every two weeks of recovery (or fraction thereof) that would be required. Use the hit location rules; e.g., surgical damage in excess of HT/2 to an arm or leg is ignored, but may cripple the limb. A critical failure may double this damage or, at the GM's option, result in other side effects instead of direct damage (e.g., surgery to improve eyesight might cause Blindness, cosmetic surgery could reduce Appearance).

Types of Surgical Procedures

Surgical procedures are grouped into these categories: *Bodysculpting* (p. 61), *Transplants* (p. 65), *Neurosurgery* (p. 70) and *Tissue Engineering* (p. 72).

Bodysculpting

Bodysculpting (also called "biosculpting") includes cosmetic surgery, muscle grafting and sex-change operations. While some changes may shock the traditional, bodysculpting is usually available and legal in all but the most conservative societies. TL7 cosmetic modifications rely on surgery, tissue grafts taken from other parts of the patient's body and injections or implants of inorganic material. TL8+ bodysculpt is more precise, with computer axial tomography scans to produce 3-D "before and after" models, laser scalpels and vat-grown collagen implants.

Altered Appearance (TL7/8)

"My parents were both neo-goths, and they had me gengineered to fit the ideal – you know, pale and thin, with these huge, dead-poet eyes and ink-black hair. It was just so ***tacky.*** *The day I turned sixteen, I went down to the Novabody and got it changed."*
– Gabrielle Ravenwood

"When I was back in LA, we'd run into poser gangs where everyone looks like Nixon or Cthulhu or whatever – or almost look, this being street medicine. I helped shut down this black clinic that was kidnapping street people and turning them into doubles of famous grid stars, then renting or selling them as toys."
– Detective Cody Chase, Nevada PD

Statistics: Select any level of Appearance, as well as facial looks, hair color, eye color and ethnic features. Point cost is the difference between the original and new Appearance. Appearance can't be increased above Very Handsome/Beautiful.

Operation: To decrease Appearance by any number of levels, or to change features so that an acquaintance needs an IQ roll to recognize you, costs $500 (and takes one week to recover from).

To increase Appearance by one level costs $1,000 (and takes 2 weeks). Two levels cost $5,000 (and 3 weeks), and the same degree of surgery can alter appearance to make someone unrecognizable, or give him a recognizable but inexact copy of another's face ("You look sort of like Elvis."). However, if a person naturally looks like another person (excluding hair and eyes), he may be modified to look *exactly* like his near-double for the price and time quoted above.

At TL8+ only, to increase Appearance by three levels takes $25,000 (and 3 weeks). The same effort can also turn someone into an *exact* duplicate of another person (as much as height and build permit), including that person's level of Appearance. *Removing* a person's finger-, palm- or footprints (TL7) takes $2,000 and 2 weeks; *changing* them (TL8) costs 10 times as much.

All changes are LC 6 (except changing prints, which is LC 3). However, making exact copies of a famous person may be a copyright or trademark violation!

Altered Bulk (TL7/8)

*"When I told the doc I wanted to **gain** weight, he was shocked. I told him it was for a movie – well, I wasn't going to admit I needed some extra room to hide my flesh holster, was I?"*

– Detective Cody Chase, Nevada PD

Fatty tissue can be removed surgically through techniques such as liposuction, or it can be grafted onto the body.

Statistics: Bulk can be safely altered up or down by one step. The steps range from a maximum of Very Fat (-20 points), to Fat (-10 points), Overweight (-5 points) and normal weight, down to a minimum of Skinny (-5 points), in that order. After the operation, adjust weight accordingly.

Operation: $5,000 (and one week). LC 6.

Extreme Sexual Dimorphism (TL7/8)

Would you like to make onlookers pant with lust or moan with envy? Come to Novabody, where we can turn you or your partner into the stuff of fantasy. Our fast, safe biosculpt procedures exaggerate primary male and secondary female sexual attributes, with striking results achieved in hours!

– Novabody: *Nirvana is Now*

*"Yes, you too can be stacked like a pleasure bioroid. No thanks. I've heard rumors that the majority of Novabody's clients work for, quote, escort services, unquote, and that some of the surgery is a little less than **elective,** if you take my meaning. Custom cuties, anyone?"*

– Detective Cody Chase, Nevada PD

Statistics: Sex Appeal +3 (3 points) plus Unnatural Feature (exaggerated sexual features, -5 points). *-2 points.*

Operation: $5,000 (and one week). It is usually preceded or followed by surgery to increase Appearance. LC 5.

Hair Graft (TL7/8)

At TL8+, living hair or fur strips may be grafted onto certain parts of the body, such as the spine, ankles or wrists, for an exotic look. Of course, it's also possible to cure baldness this way; this is TL7 rather than TL8, and is half as expensive.

Statistics: Usually a 0-point feature, but may qualify as an Unnatural Feature.

Operation: $1,000 (and one day). LC 6.

Sex Cha nge (TL7/8)

It's fashionable for hetero parents to swap sexes after each child, so they can both have a try at being pregnant. This is perfectly healthy, but do be cautioned that some people seem to be predominantly male or female, and won't be comfortable in the other gender for the months that a natural childbirth requires. See your psychogenetic counselor first!

– Dr. Lucien Locke, *Sexmorphing and You*

The procedures and effects depend on the level of sex change:

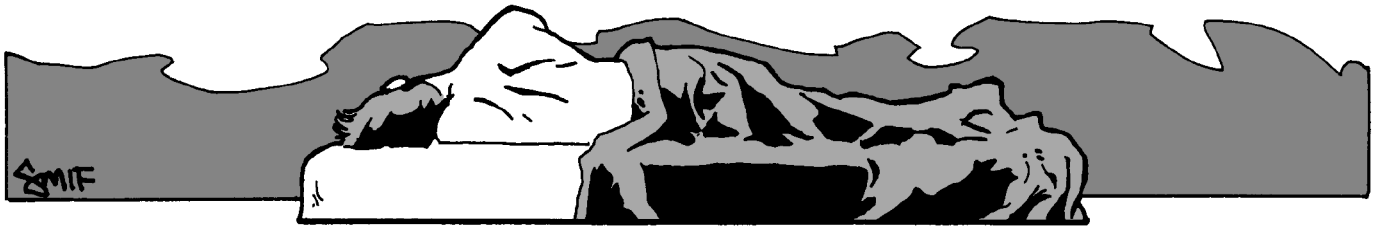
Superficial (TL7/8): The subject retains his/her own sex, but when fully dressed appears to be a member of the opposite sex.

Full Cosmetic (TL7/8): The subject completely resembles his/her new sex. Only a medical examination would reveal that a sex change had taken place. To all exterior appearances and for all social interactions, the change is total, except reproduction is impossible.

Complete (TL8): This is a total sex change, with full capacity for reproduction being possible. This requires growing a cross-sex clone (p. 16) and transplanting organs from it into the recipient's body, although at TL12+, proteus nanoviruses can design working reproductive organs and cells within the patient's own body.

Statistics: If full cosmetic, the subject is Sterile (-3 points). A functional sex change can sometimes alter personality, as a result of the hormones used and the change in self-image. At the GM's option, a sex change can justify buying off or exchanging a few mental disadvantages.

Operation: A superficial sex change is $8,000 (and 2 weeks). A full cosmetic sex change is $30,000 (and 4 weeks). A complete sex change is $30,000 (and 8 weeks) for a male-to-female change, or $100,000 (and 10 weeks) for a female-to-



male, the latter requiring the creation of an artificial Y chromosome, which is trickier. Sex changes are LC 5.

Altered Height (TL8)

Height can be altered surgically by up to 3" in either direction through adjustments to the long bones of the arms and legs. Slight modifications to the spine can add an extra 3".

Statistics: No point cost unless the modification results in Dwarfism or Gigantism (or adjusts height surgically so that the character no longer qualifies for such a disadvantage).

Operation $8,000/inch (and one week, or three if spinal). LC 6.

Archwork (TL8)

"This bold fashionmod from the spring collection of Milan bodysculptor Fox Delamere coaxes you into a ballerina's delicate, toe-first walk with modifications to the tendons and arches in the feet! Thanks to supplementary bone reinforcement, you'll be fully comfortable – and if you wear high heels, this makes a day spent walking in them as ache-free as if you'd worn flats."

– Noriko Hayakawa, host of *Cyberia Beat.*

"Sure it's striking on a supermodel like Alicia Lordes, but didn't this silliness die out in pre-space China? Still, at least Delamere set it up so it isn't physical torture any more."

– Chance Mackintosh, *Posthuman Consumer Review.*

Statistics: Adds 2" to height when barefoot, and you can wear high heels or dance shoes indefinitely without pain; regular footwear is uncomfortable (0 points).

Operation: $5,000 (and 2 weeks). You can be up and around after surgery, but treat as Lame while recovering. LC 6.

Jointwork (TL8)

Net-gossip says Macrotech caught a cat burglar picking the lock on their VP's Manhattan suite. She'd squirmed her way through the air ducts on the way in, and when Security found her, she jumped two stories and landed running. Nearly made it, too. Seemed the thief had gotten bodywork at a back-alley clinic in Kyoto: extra joints, genemod connective tissue, even some work to modify the ankles and knees for improved shock absorption. Nice job, and no patent. So they dissected her, studied the design, and reverse-engineered it into their newest product. Ironic, huh?

– Streethawk, alt.bio.upgrade.samurai.

Statistics: Any of Catfall (10 points), Double-Jointed (5 points) or Manual Dexterity +1 (3 points).

Operation: $20,000 (and 2 weeks) per advantage. LC 5.

Muscle Graft (TL8)

Tired of getting sand kicked in your face? Want the body your lover has always dreamed off? Try SpaTek's muscle grafting! Bulk up in record time while avoiding the metabolic hazards of conventional muscle-enhancing drugs and the risks of transplant rejection. Strong, safe and swift: It's SpaTek.

– SpaTek advertisement

Way I see it, muscle grafting is kind of the surgical version of steroid pushing – a quick and dirty way to bulk up real fast, if you don't have the self-discipline or the time for body building or the valuta for something more subtle. Graft's the sort of thing you'd see on MafInc muscleboys or some simstar's bodyguards. Kind of low class. Por favor, chum: Don't tell "Mountain" Mahoney I said that, or he'll break my spine.

– Streethawk, alt.bio.upgrade.samurai.livechat

Statistics: Select from +1 to +3 ST. Pay for it like any improvement in ST, except that the doubled cost for increasing ST after initial character creation does not apply. Then buy the same number of levels of Reduced Fatigue (-3 points/level), reducing the cost of the strength increase. This reflects the fact that this ST only applies to limb muscles, not to internal muscles like heart or lungs. Boosting ST by muscle grafts adds 10 pounds to weight per point of ST increase. Optionally, characters who gained +3 ST from muscle grafts can take the Unsupported Strength limitation (p. 138).

Operation: $20,000 (and 4 weeks). If using a muscle-boosting nanovirus, half the ST gain (round down) occurs after two weeks, with the remainder at the end of the growth period. LC 6.

Testicle Tuck (TL8)

"SpaTek markets this biomod for male boxers, hockey players and other such jock types, but it's a favorite streetmod as well. I've been thinking of getting one myself."

– Streethawk, alt.bio.upgrade.samurai

"Hey, hawk-baby – don't go to a street doc, okay? You make sure those blood-vessels get rerouted dolphin-style so your cajones stay cool. Don't want to bake your spunk, you know."

– Genosibyl, alt.bio.upgrade.samurai.

Statistics: Injury Tolerance (No Vitals) (groin only, -60%, 2 points). Cheap version adds Sterility (-3 points), for a total cost of -1 point.

Operation: $4,000 (and 2 weeks). Treat as Eunuch while recovering from surgery, but no bed rest is required. LC 6. Cheap version is $1,000 (and 1 week). LC 6.

Xenosculpting (TL8)

"You look surprised? I guess it must be a shock finding out your little sister has perky fox ears, fur that matches her hair and a bushy tail. And working in a hostess bar, too. I came to Tokyo with all those dreams, be a pop singer, an idol – sure, big sister, laugh. You try sleeping in Ueno park for a few weeks. After that, well, the Kitsune Club was advertising for exotic hostesses. True, the surgery and cell grafts weren't much fun, but I needed money. If I signed a four-year contract, the 'sculpt was free. Now I earn 50K a year in tips from jaded sararimen like your friend. In a year or two, I should have enough to change back. If I want to. Excuse me, sis . . . Welcome to Club Kitsune, sir! I'm Marie, your foxy hostess for this evening."

– Marie Detroit, Club Kitsune

Statistics: This gives someone nonhuman features, ranging from pointed "elf" ears to an animal-like face or head. This is a 0-point feature, but may count as an Unnatural Feature (-5 points) if such biomods are rare. Some changes – e.g., bug eyes and a sucker-like mouth surrounded by writhing tendrils – would also give a negative Appearance.

Operation: This depends on the extent of the change.

Minor cosmetic xeno-features like a pair of elf- or cat-like ears, tiny horns (too small to do damage), a forked tongue or a birdlike crest – that is, any features that don't require bone or nervous system alterations – are $5,000 (and 1 week) each. A set of related modifications (e.g., giving someone rabbit ears, buck teeth and a button nose) is $10,000 (and 2 weeks). Altered facial bone structure, like an animal-like jaw or muzzle, or modifications to skull shape, in conjunction with any desired cosmetic features, is $30,000 (and 3 weeks).

Most changes to features like the eyes or nose do not improve senses – they are cosmetic only. (Due to the need to modify the brain as well as the sense organs themselves, improvements to senses require either cybernetics or bionanotech.) The exception is large ears, which can give Acute Hearing +1 (2 points) due to the funneling of sound, cumulative with any other bonuses.

For claws, sharp teeth and so on, see *Xenostriker Grafts* (p. 66). Adding a small patch of fur or feathers (e.g., to the scalp or ears) is a "minor cosmetic change." For full-body fur, scales and so on, see *Skin Transformation Virus* (p. 78). A bunny tail or a non-functional tail that simply hangs there is a minor cosmetic modification; a tail with bone and muscle that can be wagged is a transplant; see *Tail Grafts* (p. 66).

Xenosculpting is LC 6.

Xeno-Voice Box (TL8)

Baby, you may be a hot nightclub singer, but no one, no one, betrays La Cosa. Well, your pretty mouth won't get you in trouble again. This automed you're strapped into? Benni's gonna replace your voice box. Hey baby, don't cry! Sure, you won't be able to talk no more, but you'll still be able to sing. See, we're gonna give you a songbird's syrinx instead of a larynx. Bit of brainwork, a few biochips in your skull, and you'll make us a lot of valuta at Big Al's other joint, maybe sell recordings, you know? Object lesson, we call it.

– Nanobug recording of Don C. Magaddino, from federal grand jury transcript

This technology doesn't have to be used for sinister purposes. For instance, a human diplomat might have his voice box modified so that he can speak an alien language that's nearly impossible for a human larynx to pronounce. Then he'd be modified back after completing his tour of duty.

Statistics: A human voice box altered to make animal sounds gives Disturbing Voice (-10 points) if speech is still possible, or Mute (-25 points) if it permits only animal sounds. Mute can be combined with Voice (10 points), if the animal sounds are pleasant. Modifying a human to speak a very alien language is also treated as Disturbing Voice, as human speech will be garbled.

Operation: $10,000 (and 2 weeks), or $20,000 (and 4 weeks) to combine Mute with Voice as described above. Reversing the effects of a xeno-voice box operation takes the same time and cost as the original procedure. A person can also be surgically rendered Mute with *no* ability to make sounds; this can be done quite safely at TL6, and is $500 (and 1/2 week). LC 4.

Eros Plus (TL9)

With the new Eros Plus, you and your partner can climb undreamt-of peaks of sensual pleasure! Let our trained biotechs improve on nature's gifts. Available for all sexes.

– Novabody: *Nirvana is Now*

Statistics: Your erogenous zones are twice as sensitive to pleasurable stimulation as an ordinary person's. This can be enjoyable, but you are -4 to resist Interrogation or Fast-Talk *during* such activity. The net cost is 0 points. This biomod can be addictive. For the first 1d months after it is added, the GM can require a Will roll to avoid acquiring the disadvantage Lecherousness (-15 points).

Operation: $5,000 (and 2 weeks). LC 5.

Transplants

Need a new or better body part? Why not just graft one on?

Transplants aren't new technology. The first successful organ transplant occurred in 1954, when a man with failing kidneys received a transplant from his twin brother. (Kidneys come in pairs, so it's possible to give one up for a transplant and still survive.) A twin was needed because of the major difficulty of transplant operations: tissue rejection.

Rejection occurs when the body's proteins work together with antibodies to destroy foreign tissue, treating it as an invading organism. The result is an inflammatory response, infection and possible death if the transplant is not removed. The best way to fool the immune system is to have tissue that is genetically identical. In nature, this means tissue from a twin.

Since few people have identical twins willing to donate their organs, tissue from non-genetically-identical sources is usually used instead, and immune response is suppressed with drugs. In the future (late TL8+), "blank mind" clones may be grown and used as donors – see *Clones as Spare Parts* (p. 17).

A more practical alternative is to grow individual body parts – see *Vat-Grown Organs and Parts* (p. 17). These may also be genetically altered, so that modified body parts can be grown and harvested. Such "biomod transplants" may serve as the organic equivalent of cyberwear. It may also prove possible to modify animals (such as pigs) to grow tissue – see Chapter 4.

The Transplant Procedure

Before a biomod transplant can get underway, the surgeon must have the limb or organ that is to be transplanted. Each organ or limb transplant has a listed "time to grow" in weeks. This assumes the biomod is custom-grown in a forced-growth tank (p. 19) using samples from the subject's cells. If forced-growth technology does not exist, read "weeks" as "months."

There may be faster ways to get a biomod body part. Some companies resell "used" (salvaged or repossessed) body parts, often on the black market. These can be purchased with *no* waiting period, but as they are not tissue-matched, there's a danger of rejection – see below.

The prices given for the transplant procedures in this chapter include the cost of growing or otherwise purchasing the body part as well as the operation itself, with one-third of the cost being the cost of growing the part and the remaining two-thirds representing the cost of the operation. Most transplant providers require advance payment before they will begin growing a transplant.

Once it's ready, the biomod can be attached immediately. Use the rules under *Surgery Skill Rolls* (p. 61). The patient must rest and recuperate afterward, and each procedure has a listed recovery time. If the transplant came from a non-identical donor (i.e., not a clone, twin or vat), then there will be a risk of tissue rejection – see *Rejection and Immunosuppression* (below) for the dangers and effects.

A biomod organ or limb can be stored until it's convenient, with the operation being performed and paid for at a later date. Similarly, if a group of cyberpunks were to salvage an organ from a body, they'd pay two-thirds as much. If they performed the operation themselves, they'd pay only one-third cost. If they did both, the process would be free.

Rejection and Immunosuppression

Rejection is a risk when using transplants that are neither from a donor who's the clone or identical twin of the recipient nor vat-grown. The danger can be reduced by using genetic tests to find donor tissue that more closely matches the recipient (mid-TL7); if genetically-matched tissue is unavailable, then the recipient should only accept tissue from a donor of the same blood type. Use of donated tissue is usually combined with a cocktail of drugs used to suppress the patient's immune system long enough for the transplant to become part of the body. Check for tissue rejection mid-way through the recovery period.

Rejection is automatic if the donor and recipient have different blood types. Otherwise, a HT roll must be *failed* to avoid rejection. Modify the patient's HT (for this roll only) as follows: +5 if no tissue matching was performed; +2 if a xenotransplant (p. 66). If the recipient has Panimmunity or is Disease-Resistant, his bonuses to resist disease add to HT; if he has Immunity to Disease (or level 3 Panimmunity), add +10. A regimen of immunosuppressant drugs (available from late TL7 on) gives the patient -TL to HT on the roll for tissue rejection and halves (round down) bonuses for Panimmunity, Disease-Resistant or Immunity to Disease. However, this also leaves the patient vulnerable to new or existing infections – he gains the Weak Immune System disadvantage (p. CI85) for half again the duration of the recovery period after the transplant, which may require rolls to avoid catching a disease.

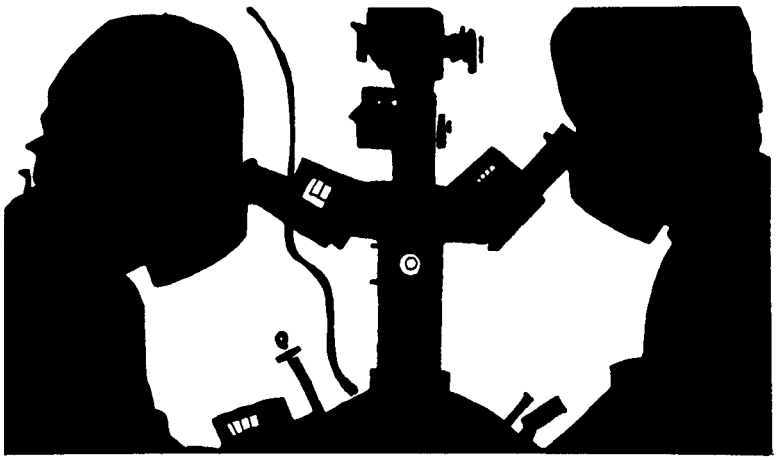
Effects of Rejection: Success on this HT roll means that rejection starts about halfway into the recovery period. The patient must make a HT roll (HT-2 if a vital organ is being rejected) every day, or lose 1 hit (1d hits on a critical failure). Don't apply any of the modifiers listed above to HT. The risk of rejection damage continues until the implant or transplant is removed or he dies. Removal requires an operation identical to the original, but is easier (add +2 to skill). If a vital organ is removed, the patient must be placed on life support until an organic or bionic replacement can be found.

Medical Transplants (TL7/8)

These are transplants of ordinary, unmodified organs, performed for therapeutic reasons: to replace organs that are degenerating or non-functional due to old age, disease or injury.

Therapeutic? Sure. But you can also use an eye transplant to change your retina print. Even saw one guy who grafted on a new hand so he could get past a palm-print scanner.

– Streethawk, alt.bio.samurai.upgrade.



Statistics: Replaces a body part. At the GM's discretion, replacing 1-3 major organs can possibly cure or arrest some diseases or terminal illnesses, or restore some or all ST or HT lost to aging, disease or radiation.

Operation: If vat-grown, 6 weeks to grow. Sample costs and recovery times for transplants: $3,000 (and 2 weeks) for a minor part like an ear or finger, $7,500 (and 4 weeks) for a liver, kidney or genitals; $15,000 (and 8 weeks) for an arm, eye, foot, hand, heart, leg or lung. LC 6.

If vat-grown organs are unavailable (or the patient doesn't want to wait for them to grow), donated organs may be used. They have the same prices, but there will be a chance of tissue rejection (p. 65). Such organs may be in short supply, with a black market that provides them to the rich or desperate. See *The Organ Trade* (p. 129) for possibilities. For another option, see *Medical Xenotransplants* (below).

Brain Transplant (TL8)

At late TL8, it becomes possible to transplant a person's entire brain and much of their spinal cord into a whole new body. Since brain cells don't regenerate, this isn't actual immortality, but it can extend the lifespan.

Statistics: The GM should "set the clock back" on any physical attributes (not IQ) lost to age, restoring them to the level appropriate for that person at his new age. Optionally, the GM may charge him the character points for the improvement, just as though improved stats were being bought normally. If brain transplants are likely, the GM may want to keep separate track of the brain's age (which will control the frequency of rolls for IQ loss due to aging) and the body's age (which controls aging losses of ST, DX and HT).

Operation: $50,000 (and 8 weeks to recover). There is no need to grow an organ, since an existing brain is used. If transplanting a brain into a person other than the original host, treat it as a braintape transfer to a different body for its effect (see *Braintaping,* p. 116). Brain transplants are LC 6.

Xenotransplants (TL7/8)

A xenotransplant involves grafting non-human tissue onto the human body. This tissue may come from an animal or be vat-grown. One difficulty with xenotransplants is that the immune response to non-human tissue is somewhat different from that to foreign human tissue. As a result, different drugs are needed to suppress immune responses, and the risk is slightly increased; see *Rejection and Immunosuppression* (p. 65).

Medical Xenotransplants (TL7/8)

These were begun experimentally at late TL7 (circa 1992) and become reliable by TL8. The goal is to replace a dying human organ, such as an infected liver, with that of an animal anatomically and genetically close to humanity, such as a baboon.

Medical xenotransplants are used for two reasons: First, they serve as a substitute for human organs that may be in short supply. Second, if the patient's organs are failing due to an infectious disease, the disease is less likely to "cross species" and reinfect the new organ than it would were cloned or foreign human tissue used. In such cases, a xenotransplant may not only repair damage but also cure the disease (this should require a HT roll, at a penalty depending on the disease).

Medical xenotransplants can be used to replace damaged or failing organs at 75% of the price of an ordinary therapeutic organ transplant and with no waiting period. Careful screening of the animal donor is performed to ensure it is healthy.

Cat's Eye Transplant (TL8)

It's cheaper and snazzier than a cybernetic eye, although it does look a bit obvious, especially in dim light when it glitters. 'Course, it can't be upgraded.

– Streethawk, alt.bio.upgrade.samurai

Statistics: Night Vision (10 points). A set of feline eye transplants may count as an Unnatural Feature (-5 points). There is a -2 to Vision rolls unless both eyes are modified.

Operation: $5,000 per eye (6 weeks to grow, 8 weeks to recover). Only a week of bed rest is needed, but the user will be blind in the transplanted eye until the full time has elapsed. LC 5.

Xenostriker Grafts (TL8)

My kid sister runs with the Unicorns, a gang of biopunks and genehackers down at the Cloisters. Vicious in a rumble, but real twisted – who else would be crazy enough to clone up narwhal fetuses and transplant the horn buds into their foreheads?

– Streethawk, alt.bio.upgrade.samurai.

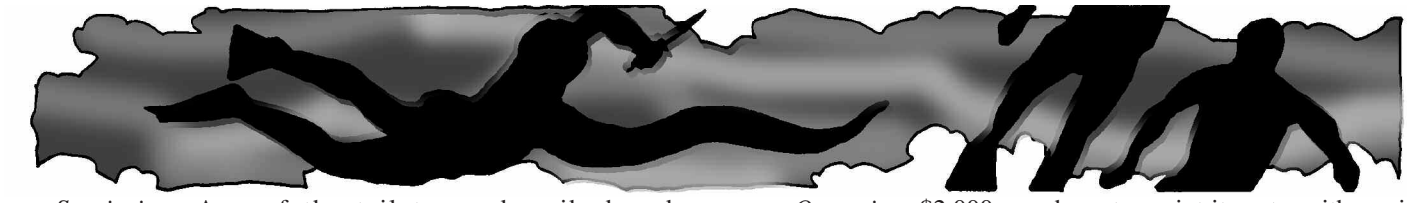
Statistics Select any striker from the *Xeno-Anatomy* table (p. 50). Claws, sharp claws, talons and sharp teeth are retractable or concealable. The others are obvious, and also count as -5-point Unnatural Features if exotic biomods are uncommon. Before the operation, the claws, talons, horn buds or tooth buds must be acquired.

Operation: Costs $5,000 × (TL-7), where "TL" is the minimum TL required for gengineering the same advantage. 6 weeks to grow, 3 weeks to recover. LC 5.

Tail Grafts (TL10)

I'm always excited by Lee Pong's creations, but this time he's outdone himself: The Novabody fall collection is stunning in its simplicity, and getting transrock diva Lyla Feng to model was a stroke of genius! Isn't her new tail just darling?

– Noriko Hayakawa, host of *Cyberia Beat.*



Statistics: Any of the tail types described under *Gengineered Tails* (p. 40) can be vat-grown and then transplanted. If biomods of this sort are unusual, a tail may be also qualify as an Unnatural Feature (-5 points).

Operation: This costs $25,000 × (TL-8), where "TL" is the minimum TL required for gengineering that type of tail. Thus, a prehensile tail (TL10) would cost $50,000. All tails take 3 weeks to grow before the transplant. Recovery time is 4 weeks for prehensile or scorpion tails, 2 weeks for ordinary tails. Tails are LC 5, except for scorpion tails which are LC 3.

Tentacle Transplant (TL12)

Okay, it's a gene-altered transplant. What I want to know is, what kind of thing they transplanted it ***from?*** *I mean, does that black clinic have a basement with some sort of stunted octopoid/human hybrid floating in a growth tank?*

– Streethawk, alt.bio.upgrade.samurai

"Oui. Some of our customers, they have odd tastes."

– M. Madeleine Rouge, the Clinic Rouge

Statistics: Tentacles can *replace* one or both arms. If just one of a person's arms is a tentacle, this is Extra Flexibility (5 points, p. CI55); if all arms are tentacles, they have Extra Flexibility (10 points).

Operation: $50,000 per arm replaced by a tentacle (6 weeks to grow, 8 weeks recovery).

Biomod Organ Transplants (TL8)

These are transplants of completely new or modified internal organs. They've been grown from gengineered clones or in special organ vats, then harvested to be ready for transplant.

Eye Upgrade (TL8)

If your eye offends thee, pluck it out and get a better one. Biomod ears or noses aren't something you can really graft on and hope for anything other than a cosmetic change, due to a lot of the processing being wetware – i.e., in the brain – but since we're better wired to handle enhanced visual input, and most of an eye's modifications are in the rod and cone cells, they're fairly easy to improve though transplants. Mind you, you can't get something exotic like infravision unless you want to mess with nanoviruses and stuff – cyber's much easier there.

– Streethawk, alt.bio.samurai.upgrade

Statistics: Cures Blindness (for 50 points), or Bad Sight, Color Blindness, Night Blindness or No Depth Perception (for 10 points each). Can add Acute Vision up to +(TL-6), to a maximum of +5 (2 points/level). It will also alter the retina print, perhaps to match another person's.

Operation: $2,000 per character point it costs, with a minimum of $5,000 (6 weeks to grow, 2 weeks recovery). LC 6.

Auxiliary Heart (TL9)

"She's not dead, damn it! Feel that slow heartbeat on the right side of her chest? Her auxiliary heart just kicked in. It's smaller than her main heart, but it should keep the blood flowing to her brain and lungs until we can medevac her."

– Lt. Dana Martello, Marine Force Recon, mission data log upload

Statistics: Extra Hit Points +2 (10 points) and Hard to Kill +3 (15 points). *25 points.*

Operation: $75,000 (6 weeks to grow, 8 weeks recovery). LC 6.

Bio-Booster (TL9)

Spring into battle with the Cheetah bio-booster! New from VeldtKorp's ace Johannesburg design bureau, the "Cheetah" adrenal pump is designed to store up and voluntarily release abnormal levels of adrenaline and noradrenaline in emergencies, supercharging you in situations where seconds mean lives. Currently under evaluation by South African, Nigerian and Israeli special forces, the VeldtKorp Cheetah epitomizes cutting-edge combat biomods at a price that can't be beaten by first-world mega-korps!

Warning: *Use of the Cheetah for extended periods is suggested only for those in good health and with normal blood pressure. We also recommend a VeldtKorp Pacesetter or other boosted heart.*

– VeldtKorp advertisement

"I had a friend who got a Cheetah. Worked fine until he got into a drawn-out fire fight in Kabul. Then his heart exploded. Guess he should have gone easy on that cholesterol."

– Captain (ret.) Dana Martello, Marine Force Recon

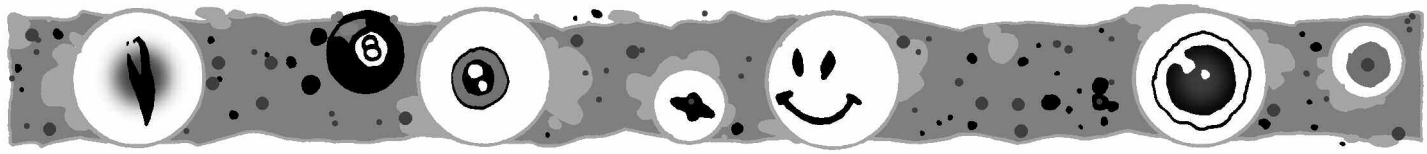
Statistics: Hyper-Reflexes and Hyper-Strength, both with Cardiac Stress, -40% (see p. 137). *27 points.*

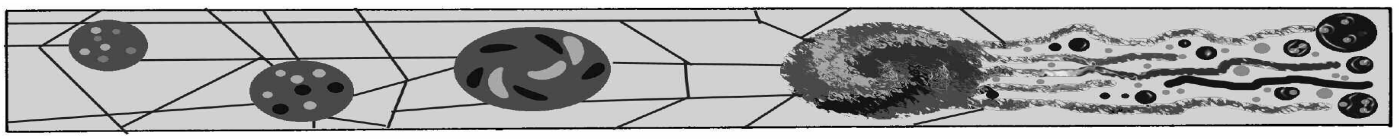
Operation: $27,000 (4 weeks to grow, 2 weeks recovery). LC 5.

Boosted Heart (TL9)

Why stick with what nature gave you? VeldtKorp's Pacesetter transplant features genemod muscle tissue and modified ventricle construction for greater strength and longer endurance. Say goodbye to cardiac unrest with VeldtKorp's Pacesetter!

– VeldtKorp advertisement





Fine if you want to undergo heart surgery just to get a few minor improvements, but I must say I'm ***personally*** *a teeny bit skeptical. I'd suggest waiting until Biotech Euphrates develops the nanosurgeons to do the modifications without cutting you open. A little bird tells me they're working on it in their Cairo facility right about now.*

– Chance Mackintosh, *Posthuman Consumer Review*

Statistics: HT +1 (cost varies), Extra Fatigue +1 (3 points), Hard to Kill +1 (bonus also applies to Aging rolls and to any rolls made to avoid heart attacks; e.g., from electric shocks or the Cardiac Stress limitation; +20%, 6 points). Costs 9 points, plus the cost of +1 HT. Pay for that like any improvement in HT, except that the doubled cost for increasing HT after initial character creation does not apply.

Operation: $28,000 (6 weeks to grow, 8 weeks recovery).

High-Efficiency Kidney (TL9)

Planning to live as a drylander? You can't always depend on canteens – even the best vapor models can malfunction, forcing you to rely on stored water. So be safe rather than sorry, and conserve water the natural way, using a High-Efficiency Water-Cycle Kidney, from Colonial Genetics.

– Colonial Genetics advertisement

The kidneys filter everything out of the blood and then selectively reabsorb those substances that your body needs, while excreting waste material into the urine. There's some waste in the cycle, though, so this modification super-concentrates your urine to reclaim as much water as possible. Never used one in the desert, but it made long road trips a lot more comfortable.

– Copernicus Jones, *Roughing it on Mars.*

Statistics: Decreased Life Support (half normal water requirement, use bathroom half as often, 10 points).

Operation: $20,000 (6 weeks to grow, 4 weeks recovery). LC 6.

Hyper-Lungs (TL9)

Gain the stamina of an Olympic athlete with Colonial Genetics' new Marathon-series augmented lung transplants! Specially strengthened with extra gas-exchange efficiency, human trials have demonstrated a substantial increase in breath-holding capacity and a boost to overall stamina. Perfect for outdoor sports and activities, the Marathon is the lung of choice among augmented professional lifeguards. Various models available, with wide range of custom features.

– Colonial Genetics press release

The last volume of ***Jane's Combat Biomods*** *says the Marathon is standard-issue for the U.K.'s Royal Marines, with a few extra upgrades, like a filtration membrane. Now I know why Brigadier Lisa Rutherford-Hodge was so blase about smoking six packs a day. 'Course, that's nothing – I hear Navy SEALS have gills these days.*

– Captain (ret.) Dana Martello, Marine Force Recon

Hyper-Lungs comes in both civilian and military ("milspec") models.

Statistics: Breath-Holding 1 (2 points), Extra Fatigue +2 (6 points) for 8 points. Milspec model adds Filter Lungs (5 points) and cost 13 points.

Operation: $16,000, or $26,000 if milspec (6 weeks to grow, 8 weeks recovery). LC 6.

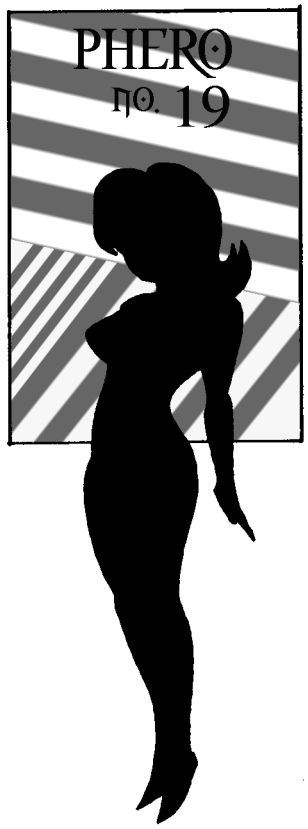
Liver Upgrade (TL9)

The liver is a chemical factory and purification system where enzymes restructure molecules into substances useful to the body, and in which detoxification of harmful substances occurs. "Team Babylon," led by Dr. Sayyid Iqbal, is proud to announce that we have once again improved upon nature. Enjoy faster and safer metabolization with Biotech Euphrates' new liver upgrade!

– Biotech Euphrates press release

"One of my best hoverjocks had a drinking problem. His own business, until he smashed up the rig and lost me six pharm goats worth sixty grand. So I said if he wanted to keep working for me and wouldn't get a rehab chip, maybe he should make an appointment with Dr. Iqbal."

– Eden Harrier, Harrier Import/Exports



Statistics: Alcohol Tolerance (5 points) and Resistant to Poison (5 points). *10 points.*

Operation: $20,000 (6 weeks to grow, 4 weeks recovery). LC 6.

Perfume Glands (TL9)

New from body designer Lee Pong, with chemical coding by Medea Cosmetics. Perfume your bodily excretions with a neutral deodorant, or produce one of a half-dozen musks and fragrances (custom-selected when the glands are ordered).

– Noriko Hayakawa, host of *Cyberia Beat*

Statistics: Generic +1 reaction (Scent-based, -20%, 4 points). With a second of concentration, the user can change between the perfume or deodorant, or if desired, go back to his own, natural body odor (but an earlier choice will linger for several minutes). By changing his scent, the user can also confuse beings that rely heavily on their sense of smell for personal identification and tracking prey – halve the normal bonus for Acute Taste and Smell or Discriminatory Smell on rolls to identify or track. The effect on other species may be unpredictable!

Operation: $8,000 (4 weeks to grow, 2 days recovery). LC 6.

Spleen Augmentation (TL9)

Fresh out of Exon-Horizon's Barcelona genetics lab comes the augmented macrospleen: An integral part of the body's defense mechanisms has been further modified to produce enhanced versions of disease-fighting white blood cells! Enjoy a longer and healthier life with Exon-Horizon biotechnology.

– Exon-Horizon press release

Statistics: Disease-Resistant (5 points) and Longevity (5 points). *10 points.*

Operation: $20,000 (3 weeks to grow, 4 weeks recovery). LC 6.

Super-Pheromone Glands (TL9)

When Colonel Chang enters the room, all heads turn to look at her, and we hang on her every word. It isn't just her fine aristocratic features, or the black and silver uniform of Special Projects. It's something else, a natural air of command, even of awe, that she projects to all those around her.

– Ensign Chun Yuan, war diary.

"The Overlord-series super-pheromone gland has performed admirably in all test subjects, releasing controlled amounts of synthetic pheromones via the sweat glands. These are tailored to induce states in human or near-human metabolisms that correlate not merely with attraction, as in early pheromone gland designs, but also dominance and awe. Obvious applications are in intelligence-gathering operations and command and control."

– Dr. Tse Chang, Special Projects Division

Statistics: Charisma +4 (Scent-based, -20%; no effect on non-humans, -5%; 15 points) *plus* Pheromone Control (25 points). *40 points.*

Operation: $40,000 (4 weeks to grow, 1 week recovery). LC 3.

Option: Allow pheromone glands that produce the Charisma bonus (15 points, $15,000) *or* Pheromone Control (25 points, $25,000) but not both.

Limb Replacement Transplants (TL9)

Avatar Klusterkorp knows true belters and voidflyers agree: In zero-G, feet are dead mass. If you're a spacer who's vowed to never get sucked down a gravity well again, you owe it to yourself to replace both feet with another pair of hands! Modified joints and digitigrade morphology allow knees to double as elbows for these fully-prehensile feet, while cutting-edge neurotransmitter injections ensure trouble-free nerve connection. Reject dirt-mode vestigals for post-human morphs now!

– Avatar Klusterkorp promotion

Gengineered arms, legs, hands or feet can be grown to *replace* the body's own limbs. The original limbs are surgically amputated, then modified limbs are grafted onto the stumps. If the subject intends to return the limbs to normal later on, the amputated limbs can be preserved for potential reattachment, saving the time required to grow new ones. Nanomachines and neural surgery are used to create new nerve connections that enable the modified limbs to be used.

Statistics: These are based on the genemods described under *Morphological Changes* (p. 39). Both legs or feet can be replaced with altered limbs (see *Modified Limbs,* p. 39) and arms can be replaced with gengineered wings (see *Arms to Wings,* p. 41). The statistics and point costs are as described in Chapter 2; the genetically-engineered body parts take 6 weeks to grow.

Operation: This costs $50,000 × (TL-7), where "TL" is the minimum TL required for the gengineering. Thus, prehensile toes (TL9) would cost $100,000. Recovery time is 8 weeks.

Polykeratin Grafts (TL11)

Polykeratin is a form of synthetic, vat-grown, biomimetic bone, cartilage or muscle tissue, based on sensa-skin (p. UT95), bioplastic (p. UT17) and memory plastic (p. UTT18) technology.

Sometimes described as "memory tissue," polykeratin cells can "remember" a second shape, and switch between shapes upon receiving certain muscular signals (which depend on the graft). Polykeratin implants permit a *limited* form of flesh-morphing – an individual with one will have the ability to alter a particular body part between two specific, different forms.

Polykeratin grafts are treated as surgery. They have no chance of rejection, but (unlike sensa-skin) are not removable without surgery.

Arm Blade (TL11)

Macrotech Biocybernetics' weapons division is proud to announce the arrival of our latest polykeratin combat implant! Clench your fist while extending your index finger, and your forearm morphs into a lethal, serrated fighting blade! Perfect for situations where guns are illegal, but a blade is too inconvenient or obvious to carry.

– Macrotech advertisement

Statistics: Long Talons with +1 reach (Takes Extra Time: two seconds to transform arm or turn back, -10%; Nuisance Effect: One Hand while transformed, -15%; 45 points).

Operation: This is a single arm replacement transplant. $45,000 (4 weeks to grow, 8 weeks recovery). LC 3.

Battle Jaw (TL11)

"You can't take any weapons into Darkside Arcology – their security is too good. But we can transform you into a weapon, agent Yukio. We'll replace your jaw with a polykeratin graft. Bite your tongue and grin – that signals the implant. Your jaw and face will morph into a battle jaw that you can extend out like an egg-eating snake. This should impress those downsiders and give you an inroad with the Cthulhugangs."

– Dr. Mara Omokage, Omokage Labs

Statistics: Fangs with +1 reach (Takes Extra Time: two seconds to transform jaw or turn back, -10%; Nuisance Effect: Mute and Monstrous while transformed -50%; 6 points).

Operation: $24,000 (2 weeks to grow, 3 weeks recovery).

LC 4.

Polykeratin Disguise (TL11)

"Connective tissue throughout your body, and particularly your face, stomach and chest, has been partially replaced by multiple polykeratin grafts and sub-dermal inflatable pouches. With the proper exercises and biofeedback regime, these will enable you to vary your apparent shape and bulk, and hold this appearance for a short period of time. Additional modifications to your spinal discs allow voluntary compression for a 5% decrease or 2% increase in height. The polykeratin implants have been supplemented by chameleon-like responsive chromatophores in all surface tissues, which can slowly alter pigmentation, while your altered hair cells can stiffen or lie flat, varying apparent length."

– Dr. Mara Omokage, Omokage Labs

"So, basically, I can look like someone else. But not for very long."

– Agent Yukio

Statistics: Elastic Skin (Costs Fatigue, 1 point/minute, -5%, 19 points). At TL12+, Elastic Skin (20 points) that can hold a shape indefinitely is possible.

Operation: This is treated as surgery. $200,000 (and 8 weeks recovery) for TL11 type, twice that for TL12. LC 4.

Quadragraft (TL11)

Macrotech Biocybernetics is happy to present the next in its series of polykeratin implants. Designed for the colonial and street markets, our transplant techs will replace your arms and legs with patented polykeratin limb grafts. When triggered, your legs become digitigrade (like a dog's) while your hands transform into walking paws. Why walk the dog when you can run with him? Perfect for high-speed scouting and wilderness fun. Enjoy posthuman thrills with Macrotech Polykeratin!

– Macrotech advertisement

My last Earthside hunt was for the killer of two of our missionaries, who had been torn apart. I suspected a psycho killer, but I must say I was caught by surprise when my quarry transformed into a werebeast. It was an interesting fight. After I analyzed the remains, it turned out he had a polykeratin battle jaw and some of that high biotech fur. It's amazing the kind of contraband that gets through our blockade.

– Tisephone Logos, >warangel>heavenweb>solnet

Statistics: Extra Legs (4 legs) *plus* Enhanced Move (Running) 2, both with Takes Extra Time: two seconds, -10% and Nuisance Effects: Horizontal and No Fine Manipulators, -40%. *13 points.*

Operation: $65,000 (4 weeks to grow, 8 weeks recovery). This includes four replacement limb transplants. LC 5.

Sensa-Skin Grafts (TL11)

Sensa-skin is artificial, vat-grown living tissue with an affinity for living flesh. Sensa-skin placed in extended contact with flesh will actually grow into it over time. Sensa-skin makes biomod transplants simpler and safer, due to its unique ability to bond with living flesh.

The effects of *Altered Appearance* (p. 61), *Altered Bulk* (only to gain in bulk; p. 62), *Extreme Sexual Dimorphism* (p. 62), *Sex Change* (Full Cosmetic or Superficial; p. 62), *Skin Transformation Virus* (p. 78) and *Xenosculpting* (p. 64) can all be produced through sensa-skin at TL11+. Treat these as normal surgical or transplant procedures, except that there is no "surgery" as such – the sensa-skin is simply carefully attached. There is no need to wait to grow transplants, no chance of rejection and no recovery time. The application time for a pre-designed sensa-skin graft is one hour for every week that a normal transplant or surgery would require to recover from. All sensa-skin grafts can be removed without surgery up to HT×3 hours after the operation takes place, using the same procedure; after that they are permanently attached and would require surgery to remove.

For more uses of sensa-skin, see pp. UT95-96.

Neurosurgery

Surgical modifications to the brain and central nervous system may be performed for non-therapeutic reasons, either to enhance the way the brain functions, or more commonly, as a form of behavior modification. If neurosurgery is performed on someone with the Compartmentalized Mind advantage, the GM should decide whether it will only affect one "compartment" or the entire mind. In general, a neurosurgeon who is unaware of the subject's ability will only be able to affect one of the compartments.

Prefrontal Lobotomy (TL6)

This radical procedure involves destroying the prefrontal lobe of the brain, which generates certain aggressive tendencies.

Statistics: Prefrontal Lobotomy disadvantage (-15 points). IQ will also drop by 2 (cost varies). See p. CI93 for other game effects.

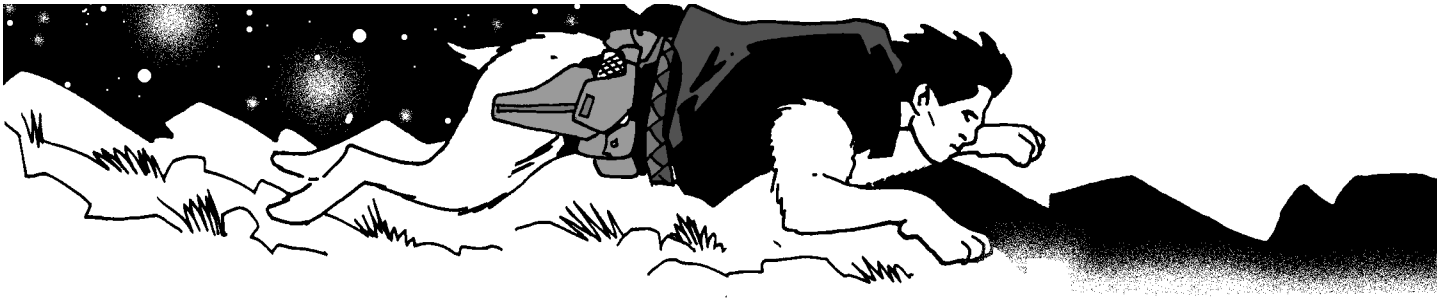
Operation: $2,000 (and 1 week). LC 4.

Killjoy (TL7/8)

This procedure burns out or removes the brain's pleasure center, usually via microsurgery.

Statistics: Someone who undergoes a Killjoy should replace any disadvantages that drive him to seek physical pleasure (e.g., Compulsive Carousing, Lecherousness) with the Killjoy disadvantage (-15 points), and pay off any point difference. See p. CI91 for other game effects.

Operation: $8,000 (and 1/2 week). LC 4.



Brain Tissue Graft (TL8)

Extra brain tissue is grafted onto the frontal lobes to increase the brain's surface area. The skull is slightly surgically enlarged to accommodate the additional grey matter. Exhaustive brain monitoring and therapy are used to ensure the smooth integration of the brain tissue into the cerebrum and prevent the impairment of existing cognitive functions.

Statistics: Adds +1-2 to IQ (pay for it normally, except that the doubled cost for increasing IQ after initial character creation does not apply). The bulging forehead is an Unnatural Feature (-5 points). If the brain tissue was a transplant from a person (as opposed to vat-grown tissue), there's a 1 in 6 chance that a few "memories" of the original donor may survive. This is reflected by giving the recipient 1d points worth of the donor's skills, plus the Flashbacks disadvantage (p. CI90). Brain tissue transplants from psis may also grant half the psi *power* of the donor.

Operation: $20,000 (2 weeks recovery). Even generic brain tissue grafts won't be attacked by the immune system (due to the blood-brain barrier). However, the difficulty of assimilating new brain matter means *de facto* rejection is possible – make a HT-1 roll to avoid it (HT+2 if using fetal brain tissue), with failure resulting in -1 IQ per point the roll failed by. Critical failure causes death within 1d days. LC 5.

Hotshotting (TL8)

"Your daughter is having trouble with her mathematics program? She spends all her time in parties, with her boyfriend or living sensies? Perfectly understandable. These activities are more pleasurable to her, you see. But we at the Clinic Rouge can repair that for you. We will simply rewire her pleasure center to that part of her brain that governs mathematical and analytical activity. As long as your daughter is working on such problems, she will be excited, even aroused, as if she were with a lover, or eating chocolate. Sign this consent form, and our operatives will pick her up after school."

– M. Madeleine Rouge, the Clinic Rouge

This is a specialized form of psychosurgery. You can get hotshots for almost anything: cooking, washing dishes, sports, fighting, even netrunning. They monitor you and find the deep structures laid down in the brain as you do things. The result's the ultimate in positive reinforcement. Existing reinforcers like sex or eating can be hotshotted to make them even ***more*** *pleasurable, too. Heck, half the hookers on the strip are sex hotshots, so their pimps don't even have to buy 'em drugs. I've heard some korps will pay an employee a bonus if he agrees to the procedure. Yep, hotshotting makes you happy, eager and more productive. It also makes you less human.*

– Professor C. Eric Gideon, sci.bio.posthuman.rant

Statistics: This is treated as an Addiction (p. B30) to the endorphins produced in the brain when the hotshot activity is performed. To get his daily fix, the character must spend at least two hours on the activity. He becomes Single-Minded while doing so (+3 to skill if concentration is required). Missing the hotshotted activity causes withdrawal. Point cost is variable: hotshotting may be worth 0 points if the hotshotted activity is something useful, such as a socially-acceptable profession; otherwise, it tends to be as self-destructive as any drug addiction – treat as a cheap, highly-addictive drug (-10 points).

Continued positive reinforcement will usually cause a hotshotted person to develop other disadvantages closely related to the focus of his hotshot. This is usually Compulsive Behavior, but other disadvantages may be appropriate: Bad Temper (if hotshotted toward combat activity), Lecherousness (if a sex hotshot) or Workaholic (if the hotshot is related to his job).

A hotshot may also have tertiary effects, at the GM's discretion. Within months of hotshotting, some personalities may eat less (losing any Fat or Overweight disadvantages and eventually becoming Skinny), neglect grooming (lowering Appearance) or talk of nothing but their hotshotted activity (Odious Personal Habit).

Operation: $10,000 (and 1 day). LC 4.

Note: This greatly expands on the existing rules for hotshotting (p. CY17). GMs who prefer the original rules are free to continue using them!

Psychosurgery ("Deadheading") (TL8)

Prison? Don't be a fool. In our country, we don't have political prisoners, just sick people who need to be cured. Now lie down here and we'll hook you up to the holographic brainscan. I'll ask you a series of questions. Won't talk? Don't worry. We can measure your neurological responses, and we'll know exactly which area of the brain to . . . Hold him, nurse! No, I'm not going to "cut" your brain. We once used laser or meson beam cauterization, but we've progressed far beyond that. I'll inject cellular microsurgeons, which will operate on certain areas of your brain. Your fanatical obsessions will be cured for good. You'll become a normal, productive citizen. It's quite painless, and you won't feel a thing. Never, ever again.

– Dr. Tse Chang, transcript of psychosurgery session

A psychosurgical ("deadheading") procedure selectively obliterates a tiny area of the brain via micro- or nanosurgery. It is similar to a lobotomy, but orders of magnitude more precise, enough that it is useful for both behavior modification and therapy.

Statistics: Deadheading can produce a wide variety of effects, depending on the surgeon's skill and desires.

It can destroy any of these advantages: Absolute Direction, Absolute Timing, Alertness, Ambidexterity, Charisma, Chronolocation, Combat Reflexes, Common Sense, Deep Sleeper, Eidetic Memory, Empathy, Enhanced Time Sense, Intuition, Language Talent, Lightning Calculator, Literacy, Mathematical Ability, Musical Ability, Pious, Rapier Wit, Sensie Talent, Sensitive, Strong Will, 3D Spatial Sense and Versatile. It can also lower IQ by up to three points. If Magery or psionic powers are understood, it may remove them as well.

It can give someone mental disadvantages that represent the loss of mental faculties, including: Absent-Mindedness, Amnesia, Callous, Cannot Learn, Chronic Depression, Clueless, Combat Paralysis, Confused, Distractible, Dull, Dyslexia, Gullibility, Hidebound, Illiteracy, Incompetence, Incurious, Indecisive, Killjoy, Low Empathy, No Sense of Humor, Non-Iconographic,Obdurate, Oblivious, On the Edge, Short Attention Span, Staid and Weak Will.

It can cure any *mental* disadvantages except those listed above, Prefrontal Lobotomy and Unluckiness. Thus, it could be therapy, removing a Delusion or Phobia. At TL9-10, this must be balanced by adding a new disadvantage (or removing an existing advantage) from the list above whose point total is worth at least half as much as the disadvantage cured. Thus, you could burn Fanaticism (-15 points) out of someone's brain, but you might leave him Confused (-10 points). At TL11+, deadheading is more precise – it can cure mental disadvantages as above, but without replacing them with others. Deadheading can also create targeted (but generalized) amnesia around specific memories and their associations.

Operation: $1,000 times point change (1 day recovery), minimum $10,000. Before psychosurgery can take place, extensive *persona mapping* is required, requiring a successful Psychology roll and at least a day of monitoring the subject (reduce this to an hour at TL11+ and ignore it at TL13+). To reverse deadheading, use a biomod or cyberwear that restores (or neutralizes) the affected advantage or disadvantage. LC 4.

Note: This greatly expands on the existing rules for deadheading (p. CY18). GMs who prefer the original rules are free to continue using them!

Wetware Sub-Personality (TL11)

People say I'm too careful, too honest, too soft. I admit I hate the sight of blood, and I'd rather err on the side of caution. So? It makes me human. But this was too important. The ELF had the Lucifer Plague, and there were only two days left before their deadline. So before I led my team in, I had the GRA labs give me a new wetware sub-persona: the Executioner.

– Tatiana Belenko, Genetic Regulatory Agency

A development of procedures to treat multiple personality disorder, this uses neurosurgical and RNA viral techniques to construct a sub-personalty – or "inner daemon" – in the user's mind. Unlike a Split Personality, this is under his conscious control. Each daemon has its own set of attitudes, but each also shares the original's skills, memories and overall goals.

Statistics: Activating an inner daemon causes the user to lose all his normal mental disadvantages, as well as Charisma, Collected, Common Sense, Composed, Cool, Cultural Adaptability, Fearlessness, Imperturbable, Single-Minded, Strong Will and Unfazeable. However, any of those advantages, and any mental disadvantages, can be included in the wetware sub-persona. It is possible to have an inner daemon that simply erases all mental disadvantages ("zen state").

An inner daemon takes four seconds of concentration to call up (Takes Extra Time, -20%). It can only remain stable for an hour or so every day (Limited Use, 1 hour/day, -40%), which is followed by reversion to the original personality, or a different one. Find the net change in the point value of the character that was induced by the inner daemon. Then apply a -60% limitation to this total to find the daemon's point cost.

Operation: $4,000 times the total cost of all advantages and absolute value of all disadvantages *granted.* No cost for *erased* advantages or disadvantages. Minimum cost is $20,000 (1 day recovery). LC 5, or possibly lower if the daemon is dangerous or antisocial.

Tissue Engineering

Tissue engineering consists of surgically implanting synthetic (but often organic) material to improve the functioning of living organs, bones or muscles. Instead of replacing flesh the way bionics does, tissue engineering aims to enhance it.

Tissue engineering uses the rules under *Surgery Skill Rolls* (p. 61). As the tissue is synthetic, there is no chance of rejection and no need to grow specialized tissues prior to implantation. Half of the price buys the tissue, the other half the operation.

Muscle Reinforcement (TL9)

"You wish to enhance your strength in a manner that leaves no visible traces? You have come to the right place, mon vieux: the Clinic Rouge. Here, the finest nanobots will pleat high-strength elastic fibers into the muscles of your body, using a protein macromolecule that DuPont Orbital will release next month. Of course, ***we*** *have it now. The Clinic Rouge prides itself on being the cutting edge of black medicine."*

– M. Madeleine Rouge, the Clinic Rouge

"Aussie smuggler, name of Sally Strang – maybe you've seen her? Tiny little redhead with cute braids, ex-navy hoverjock. Well, we were walking along the Tokyo waterfront, eating squid and talking biz, when 200 kilos of Kobe beef starts hassling us. Meatboy puts his paws on Sal. Bad move. She grins, lifts him up and sumoboy goes head-over-heels over the rail. Splash! Guess he hadn't heard Sally'd gone to Marseille, gotten her muscles done as well as her hair. The meatboy? Hey, you know what Tokyo Bay's like these days. The bacteria ate him."

– Eden Harrier, Harrier Import/Exports

Statistics: Select from +1 to +5 ST (or double that if you have skeletal strengthening, p. 81). Pay for it like any improvement in ST, except that the doubled cost for increasing ST after initial character creation does not apply. Unlike a muscle graft, weight and looks *will not change* when this process is used. The ST increase is cumulative with other biotech-enhanced ST, but not bionics. Optionally, characters who gained +3 to +5 ST from muscle reinforcement (or +6 to +10 ST, with skeletal strengthening) can take the Unsupported Strength limitation (p. 138).

Operation: $10,000 times character point cost of the added ST (and 3 weeks recovery). LC 5.

Neural Augmentation (TL9)

Do you want to move faster than a jack rabbit on amphetamines? We at Kerensky Labs recommend our Max-9 neural augmentation process, which fuses adjacent nerve cells together to improve the diffusion of neurotransmitters across synaptic junctions and enhance nerve impulse transmission speed. To ensure optimum performance, we recommend periodic use of the neurotransmitter hormone PK-28N (Pink Noise).

– Kerensky Labs advertisement

They aren't kidding. Crank yourself up with the old Max-9 and you move so fast your brain can't handle it without some kind of help. I was partnered with this 'Maxed-out Russkie panzerbabe, name of Leona. Greased lightning – or so I thought, until one day when she tripped in a fire fight and shot her foot off. Turned out she'd run out of Pink Noise the day before.

– Streethawk, alt.bio.upgrade.samurai

Statistics: Increased Speed +3 (75 points) *and* Total Klutz (p. CI82) unless a dose of drug PK-28N ($200/dose) is taken within the week (Mitigator limitation, p. 137; weekly, over $100/dose, -60%, -6 points). Costs 69 points.

The Speed increase is cumulative with other sources of this advantage, with the exception of cyberwear that replaces the organic nervous system with electronic systems.

Operation: $330,000 (and 2 weeks), LC 4.

Note: A user can eventually get used to the Increased Speed, and buy off the Klutz disadvantage using earned points.

Chemical Enhancements

"Ever try Adders? Cute, performance-enhancing drugs, but they're pretty limited. Sure, they'll make you smarter or stronger for a few hours, but then it's a big letdown. I mean, great for combat or acing a test, but that's not much use if you've got a long-term project like a marathon or finishing your thesis, is it? But there's some drugs out there that can give you that kind of life-long boost you want. 'Course, your life may not be that long, but at least you'll leave a good looking corpse."

– Genosibyl, alt.bio.upgrade.samurai

GURPS Cyberpunk, Space and ***Ultra-Tech*** describe numerous drug treatments that can produce short-term enhancements to human performance, such as Adders (p. UT97) or Memory-Beta (p. UT99). However, it's also possible to get drugs that trick the body into making permanent changes. A short selection of drugs of this sort is described below. Feel free to create more, using these as inspiration – at TL8+, "designer drug" labs are capable of making a *wide* range of exotic chem!

Note: If drugs increase an attribute, the doubled cost for increasing attributes after initial character creation does *not* apply.

Anabolic Steroids (TL7)

These are the best-known strength-boosting drugs, synthesized from the natural sex hormone testosterone. They have a marked anabolic (growth-promoting) effect on muscle tissue, especially when taken in large doses. That's why they're so popular with athletes and body builders who wish to "bulk up" rapidly.

Side effects? In spades. Initially, the only effects may seem positive, but continued high doses of steroids have a "negative feedback" effect on the body – it stops making some of its own hormones, since it's getting them from outside. The problems associated with prolonged steroid use include sterility, aggression, muscle spasms and pain, and in some cases, cancerous tumors. In men, additional side effects include acne, balding, shrinkage of the testicles and breast growth. In women, extra side effects are cessation of menstruation, body hair growth and development of a more masculine body shape and coarser voice.

To produce a change in strength, large doses of anabolic steroids should be combined with body-building exercises for a number of weeks equal to *half* the character points required to raise ST by one. This produces these game effects:

ST +1, HT -1, Extra Hit Points +1 and 3d+5 lbs. weight increase (all muscle).

In other words, while a person's strength and bulk increase, his overall ability to resist damage stays the same, and his general health declines, representing the progressive damage that steroids do to the body. Moreover, each time ST increases, make two rolls versus (the *new*) HT+2, one to avoid acquiring each of Bad Temper and Sterile. If the steroid user has Average or better Appearance, also roll vs. HT+2 to avoid the loss of one level; likewise, if the user has the Voice advantage, roll vs. HT+2 to avoid losing that as well. Women roll to avoid Appearance or Voice loss at HT, not HT+2.

The same program can be repeated over and over again.

Availability: An anabolic steroid program costs about $40 per week. As anabolic steroids (for human use) are grey-market items, LC 5.

Example: Street samurai Gunther Chang (ST 13, HT 12) decides to increase ST to 14 via steroids. Since the difference between ST 13 and 14 is 15 points, this will take him 15/2=7.5 weeks and cost him $300. At the end of this time, Chang will end up with ST 14 and HT 11/12. He must then roll vs. HT+2 (i.e., 13) to avoid gaining each of Sterility and Bad Temper, and losing a level of Appearance. He makes all three rolls – but if he keeps taking steroids, his HT will decline, making it more likely that he will suffer these effects.

It's up to the GM whether characters should pay character points if they increase ST via steroids. If so, the cost should be based on the net change. For example, Chang's ST gain is 15 points, his HT loss is -10 points and his Extra Hit Point is 5 points, for a total of 10 points. The GM could either charge Chang 10 points, or simply raise his point total by that amount.

Nootropic Drugs (TL7)

These are "smart drugs" (mostly experimental at TL7, but widely available by TL8) – chemicals that enhance brain performance. Most smart drugs were originally designed to treat mental problems, repairing damage to the brain caused by things like alcohol poisoning, stroke and senility. They may also fight senility by clearing out cellular waste products, improving oxygen flow to the brain, or neutralizing free radicals that interfere with brain function. In healthy people, they can enhance the ability to grow connections between neurons, improving the ability to memorize (which is partially the process of setting up these connections). Some nootropic drugs also increase the levels of neurotransmitters that carry electrical signals from neuron to neuron.

Late-TL7 smart drugs include piracetam, l-dopa and vasopressin, among others. Most are delivered by pill or nasal spray. Their long-term effectiveness in healthy people remains controversial, but here's a modest interpretation: For as long as the drug is taken daily, and for one day afterward, it allows one to buy the Mitigator limitation ($20/week, -65%; see p. 137) for any of the following disadvantages: Absent-Mindedness, Confused, Distractible, Dull, Hidebound, Indecisive, Short Attention Span or Staid, and justifies buying off the disadvantage whenever the character has the points to do so.

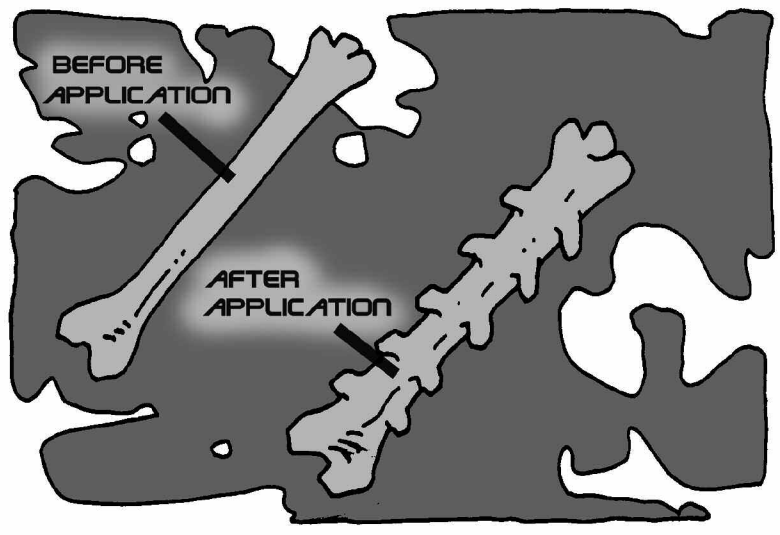
In addition, if the GM feels it is realistic, a character can buy more IQ, and the doubled cost for increasing IQ after initial character creation *will not apply*. To do this he must take nootropic drugs continuously (and since his last increase in IQ) for at least as many weeks as the point difference between his current and new IQ; e.g., someone with IQ 10 would need 10 weeks of smart drugs before he could buy IQ 11 for 10 rather than 20 points. Side effects are negligible, although hypertension and twitching sometimes occur.

Availability: $20 per week. LC 5.

Bone Stimulation (TL8)

Make your bones stronger! This biochemical process stimulates bone cell growth – I heard it's a development of some of the technologies the orbitals developed to replace bone decalcification in zero-G, before they all got their genes twanked to avoid such mundane problems.

– Streethawk, alt.bio.samurai.upgrade



This treatment gives +1 Extra Hit Point (maximum). It does not increase ST, but *does* allow muscle grafting or reinforcement to increase ST by two points more than the normal limit. It can also cure one point of ST or hit point loss due to bone degeneration in zero-G (see *Musculo-Skeletal Modifications,* p. 42).

Availability: $10,000 (and 2 weeks). Repeated treatments will not have any further benefits, except to cure further ST or hit point losses due to decalcification.

Peter Pan Process (TL8)

"The Clinic Rouge does not advertise this service, but for a regular client such as yourself, we will make an exception. Such a sweet child. How old is he? 11? 12? No, that is not too late – as long as he has not left puberty, the Peter Pan process can be initiated. Simply put, our course of synthetic hormone therapy will ensure certain growth-controlling genes do not switch on. As long as treatments continue, he will never enter adolescence. Eternal youth? Do not mistake me, monsieur. This is not an immortality process. Organs eventually fail, and after several decades, his skin will wrinkle under gravity's tug, unless cosmetics or bodysculpt are used. But for the next two or three decades, he will be a young boy."

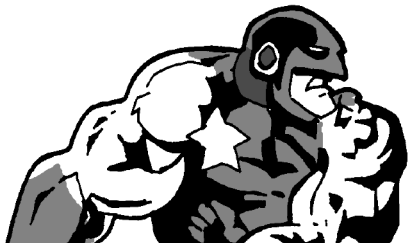
– M. Madeleine Rouge, the Clinic Rouge

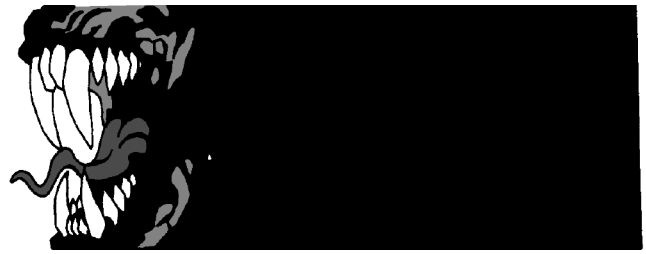
"We had the motel under surveillance for dust dealers when I spotted Mr. Suit heading for a room with a girl who definitely looked a few years pre-jail bait. Hooking's legal in this town, but not with kids. Looked like a righteous bust, so I blew the door just in time to catch the Vice President of AresKorp with his pants down. Bad move. Turns out little Wendi is 26 years old. Now the D.A. says I'm facing her lawsuit for false arrest and interfering with licensed commerce, and the captain says AresKorp wants my badge. I hate stunties."

– Detective Cody Chase, Nevada PD

These drugs can be taken by anyone with the Youth disadvantage, and effectively prevent that disadvantage from being bought off. However, aging rolls *will* be made.

Availability: The course of hormone treatment requires $500 per month to "stunt" apparent age. LC 4. Child actors, teenage gymnasts, male singers and others may be stunted to lengthen their youthful careers, but many legal systems consider "stunting" to be child abuse.





Super-Steroids (late TL8)

Advanced protein engineering may produce performance-enhancing drugs with similar effects to anabolic steroids (p. 73), but reduced risk.

After taking super-steroids for half as many weeks as the points required to increase ST by one, gain +1 ST and 3d+5 lbs. weight. Then roll vs. HT. If the HT roll is a success, there are no additional side effects. If the roll *fails,* the user loses one point of HT and gains one Extra Hit Point, much as with regular steroids. If the HT roll is a critical failure (or, if female, any roll of 16+), the use also suffers any *one* of Bad Temper, Sterility, loss of Appearance or loss of Voice, as described for regular steroids (p. 73).

Availability: $100 per week. Cost is halved at TL9 and again at TL10+. LC 5. If purchasing these on the street, be wary of cheaper, old-style steroids with new labels.

GMs should usually charge character points for improvement via super-steroids (minus any points lost to side effects).

NERV (TL9)

This drug chemically alters the neuro-endocrine system to improve reflexes and coordination. After taking NERV for half as many weeks as the points required to increase DX by one, the user gains +1 DX. Then he must roll vs. HT. If successful, there are no side effects. If the roll *fails,* the user suffers one level of Reduced Manual Dexterity (-3 points/level, p. CI83), as the drug increased overall reaction speed and agility but failed to make the neural connections needed to improve fine motor coordination. If the roll was a critical failure, neural damage was inflicted due to an accidental overdose, and (1d/2)+1 levels of Reduced Manual Dexterity are suffered instead of one level.

Availability: $2,000 per week. LC 5. "Street NERV," at half cost, is similar – but there is a -4 on the HT roll to avoid side-effects.

Genetic Surgery

Humans begin as single cell – a *zygote* – but as we grow out of the germinal stage, our cells differentiate. Every cell carries the full complement of genes, but it only uses some of them, depending on where it is in the body. This is what distinguishes skin cells, brain cells, blood cells and so on. The function of the genes in a cell may also change over time; for instance, after we stop growing, many cells switch off. While genetic engineering can be performed *after* the germinal stage, it's trickier, because instead of working on a single cell, the body now has billions, each with a different function.

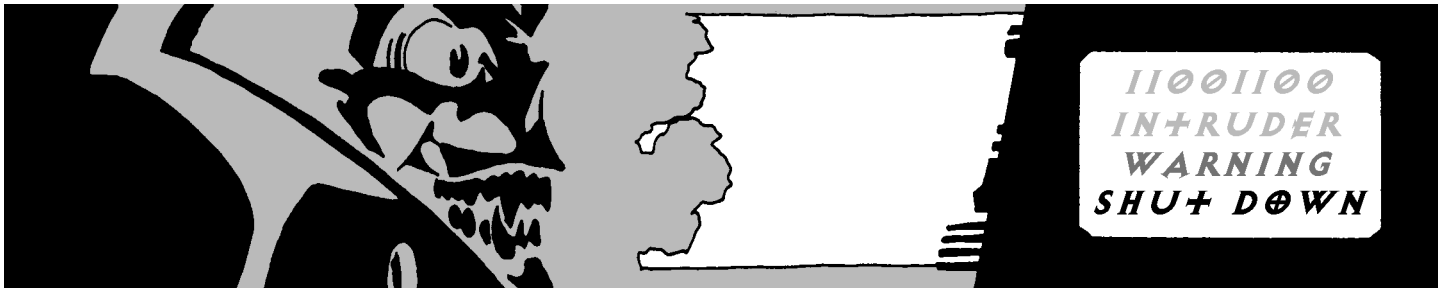
Genetic surgery cannot produce gross anatomical changes, but it may have subtle effects. For instance, it may alter the way a certain hormone is produced, with a marked effect on the recipient's behavior. At late TL7, genetic surgery is usually used to replace defective or missing DNA sequences, repairing genes so that they can produce whatever missing enzymes or proteins caused a genetic disease. At TL8+, non-therapeutic genetic surgery techniques may be developed.

Historically, genetic surgery experiments on humans began in the 1980s with "gene therapy." Problems were encountered in ensuring that the added gene properly interfaced with the body's regulatory system – that is, that it switched on or off when it was supposed to – and it either failed to make the necessary proteins or made too much of them. Today (1997), many of these problems have been overcome.

One major genetic surgery technique is the *cell transplant.* Cells are removed from the appropriate organ of the patient (e.g., bone marrow cells, if trying to modify how blood is produced). Gengineering techniques – usually tailored RNA viruses – are then used to introduce new genes into them, as described in Chapter 1. These altered cells are reintroduced into the patient, where they will hopefully thrive and replicate. At TL7, the subject is given drugs to help his body accept the new cells (see *Rejection and Immunosuppression,* p. 65, for the effects). At TL8+, cell implants are encapsulated in a specialized membrane that masks them from the immune system until they have become safely integrated into the body, while still allowing proteins to pass through – the advantage being that no immunosuppression treatments are needed. In some cases, the controlled release of cells is orchestrated by biochips (p. 138).

In some cases, actually removing cells to work on them may not be necessary, and a modified RNA virus can simply be injected into the patient. This largely depends on how specific a change needs to be made, and how confident the genetic surgeons are in their ability to target the specific cells they want to alter.

Genetic surgery processes have a listed cost and time. The required time is spent in a hospital facility. During this period, genetic surgeons are taking cell samples, running tests, performing the actual RNA injections or cell transplants (often a series of them), waiting for modified cells to replicate, observing the



results, and taking any necessary corrective measures. The patient will be confined to bed (often with diagnostic sensors attached), but is conscious most of the time.

So what can you do with genetic surgery? Some of the many possible applications are described below.

Gene Therapy (TL7/8)

If someone is born with faulty or missing genes, the body may lack the capability to make enzymes or other proteins that it needs. Depending on which genes are missing, this deficiency may cause a hereditary metabolic disease, such as cystic fibrosis or hemophilia. There are almost 3,000 such genetic disorders.

In fact, most humans and other animals carry a few defective genes. However, humans and similar higher animals have two duplicate sets of almost every chromosome and the genes they carry, one from each parent. (The exception is the male "Y" chromosome; as a result, men are more vulnerable to "sex-linked" disorders resulting from defective genes on *either* sex chromosome.) Even so, genetic disorders affect as much as 10% of the human population, although the effects of some do not manifest until quite late in life.

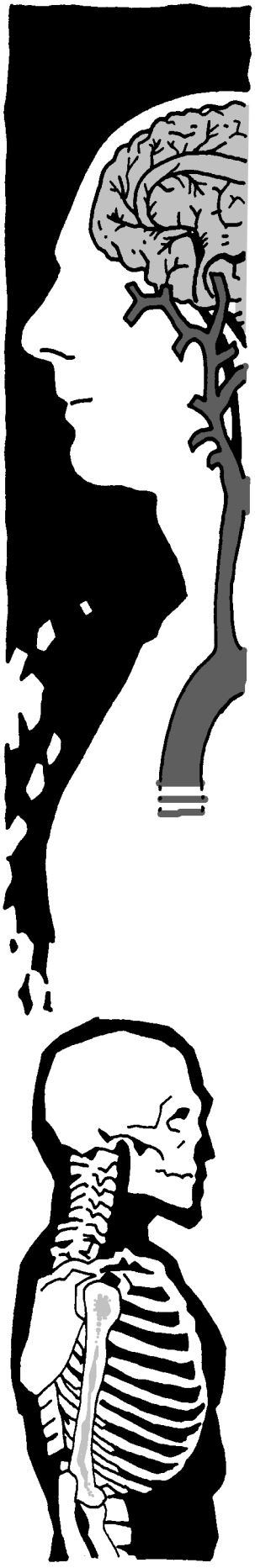
Until the late 20th century, the symptoms of genetic disorders could be treated, but the disorders themselves could not be cured. Thanks to an advance in bioengineering called *gene therapy,* is now possible to remove the root cause of a genetic disease using cell transplants (p. 75). Even so, a basic limitation on gene therapy is the need to know exactly which genes code for which enzymes or proteins, and how they relate to the body's functioning. While considerable progress has been made in cases involving a single gene, multiple genetic interactions are often involved. As human genome mapping progresses (through TL8), more complex genetic therapy procedures will become possible.

Statistics: Gene therapy can remove certain disadvantages, if they result from hereditary conditions. By late TL7/early TL8, this includes some forms of Hemophilia, Terminally Ill and Weak Immune System. By mid-TL8, it also includes Epilepsy, Migraine and Tourette's Syndrome.

During TL8, all genetically-caused forms of the above conditions can be cured gradually. In addition, in a fetus or young child, early gene therapy may be able to prevent Bad Sight, Color Blindness, Dwarfism, Dyslexia, Gigantism and No Sense of Smell/Taste.

Also at some point during TL8, gene therapy may be able to cure inherited learning or behavioral disorders. Where these disadvantages have a genetic cause, they can be removed: Cannot Learn, Chronic Depression, Gluttony, Lunacy, Manic-Depressive, Non-Iconographic, Paranoia, Short Attention Span and Slave Mentality.

Operation: $10,000 per disadvantage cured (and 2 weeks). LC 6.



Emotional Regulator (TL8)

Get into too many bar fights? Suffer from poor impulse control? Then you're the kind of personality that can use a Jen-Goku Rage Damper! Unlike cruder systems, this bio-implant doesn't prevent you from feeling emotions. Instead, this cluster of biochip-regulated cells is capable of sensing hormones and follows them up with tailored enzymes that cut them off at the pass.

– Jen-Goku Corporation advertisement

"Joji 'Madboy' Saiko got one of these cell transplants after his last assault conviction. Was it a court order? Not this time. The Oyabun's decision. The Russki-Yakuza don't admire a man with no self control. Besides, Jo had run out of little fingers."

– Eden Harrier, Harrier Import/Exports

Statistics: Hormonal dampers can justify buying off Bad Temper, Berserk or Lecherousness; point cost is equal to the cost of buying off the disadvantage.

Operation: $4,000 (and 1/2 week to recover, although it takes effect within 1 day). LC 5.

Bone Marrow Upgrades (TL9)

When I completed boot camp, the fun began. After they finished growing the new muscles, the doctors implanted modified cells into my bone marrow, altering it to manufacture erythrocytes with boosted oxygen-transport capacity. Of course, then they had to do a bit of tinkering with my gastrointestinal tract to make sure I got enough iron from our diet to keep my bone marrow happy . . .

– Captain (ret.) Dana Martello, Marine Force Recon

Bone marrow cells may be modified to produce gengineered blood cells with improved capabilities. Care is taken to ensure that the modified marrow is "smart" enough to adjust cell production so that complications like high blood pressure and other disorders do not occur.

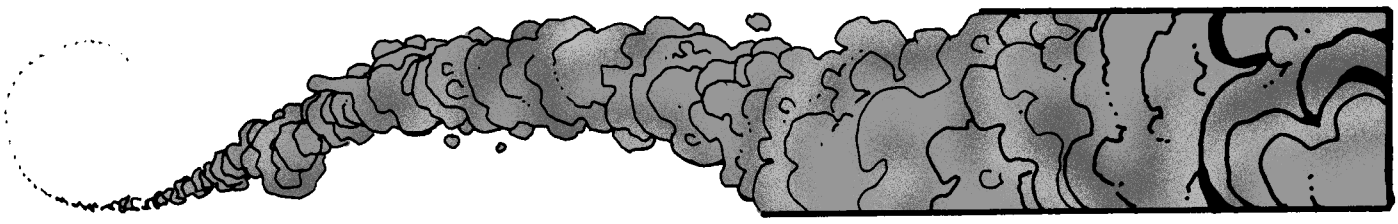
Statistics and Operation: These depend on the type of blood cells that are modified:

Enhanced Erythrocytes: The bone marrow is modified so that the red blood cells it produces possess hemoglobin with greater oxygen transport capacity. Gives Extra Fatigue +2 (6 points). $12,000 (and 2 weeks). LC 5.

Enhanced Thrombocytes: Blood platelets are redesigned for superior wound-clotting ability. Gives Very Rapid Healing (15 points). $30,000 (and 3 weeks). LC 5.

Metabolic Reset (TL9)

"Back in prehistoric times, people used liposuction and surgery to remove fat, or took pills to suppress their appetites. No, really! And afterwards, they often went right back and regained what they lost. Today, we know what genes make



your body ***want*** *to be a certain weight, and how to make RNA injections to change them."*

– Noriko Hayakawa, *"Fun Ways to Change Weight," Cyberia Beat*

Statistics: Bulk can be altered up or down one or more steps: Very Fat (-20 points), to Fat (-10 points), to Overweight (-5 points), to normal, to Skinny (-5 points) or vice versa. Adjust weight in pounds accordingly. Lose or gain one step every two weeks until the chosen stage is reached. Halve the time if the subject works with the virus via diet and exercise (or lack thereof); double the time if he tries to fight it!

Operation: $4,000. The reset operation itself requires 1/2 a week, but losing (or gaining) weight takes the time discussed above. LC 6.

Proteus Nanovirus (TL10)

Don't want to spend a couple of weeks making a pilgrimage to some super-clinic to undergo genetic surgery? Well, at TL10, *proteus viruses* become available. These "paraviruses" allow a form of genetic surgery through a single injection, with no fuss, lab tests or surgical cell transplants. On the other hand, because the virus hasn't been specially tailored, it may not always work!

Proteus nanoviruses, which are also used in germline gengineering at TL10+, are specialized bio-nanomachines, capable of being programmed to perform complex tasks. This includes *rapidly* replicating throughout the body, replacing entire cell nuclei, completely resequencing DNA and stimulating the rapid growth of newly-modified cells.

A proteus nanovirus takes 1d×5 minutes to multiply. There is a chance that the recipient's immune system may fight it off. This occurs a HT-6 roll. If successful, nothing happens. Contact with the bodily fluids of someone who is in the process of being altered by a proteus virus may also cause infection (HT-3 to avoid). In both cases, bonuses for Panimmunity and Disease-Resistant apply. However, Immunity to Disease gives only +10 to HT to resist, rather than being automatically successful. If the HT roll *fails,* the virus begins resequencing the subject's DNA and altering his body.

An almost infinite variety of proteus viruses exists. At TL10-11, a proteus virus can perform relatively "soft" changes, whose effects will be seen in altered skin cells or blood cells, modified neurochemistry and so on. At TL12+, an extremely sophisticated kind of proteus virus, called a *metamorphosis virus,* can produce actual changes in the body's anatomy.

Each proteus virus has a cost and a time required. This time is the number of days it takes the virus to replicate throughout the body and finish its work; there is no "operation" – one merely takes a pill or receives an injection. Unless using a metamorphosis virus (p. 79), *no rest is required* – the nanovirus performs the work quietly and without fuss.

Various *customized* forms of proteus virus are also possible, such as a nanovirus that spreads like a plague or which is specifically designed to affect a particular person (which means that his immune system has less chance to resist it). See *Proteus Virus Options,* p.82.

Growing Nanovirus

A proteus virus designed to produce a particular biomod (or a set of nano-symbiotes – see p. 84) can be "home grown" rather than purchased. This requires a genetics lab (p. 21) of a TL equal to or greater than that of the biomod or symbiote the nano are being designed to produce.

The nano will cost about 50% of the listed cost if the characters are paying for commercial blueprints, or 25% of the cost if they are reverse engineering someone else's nano. It takes about one hour per $1,000 the nano normally costs.

This requires a successful skill roll vs. the lowest of Biochemistry, Computer Programming and Genetics (Genetic Engineering) skills, although members of a team can contribute one skill each. Apply any modifiers for lab quality, plus -1 if the nanovirus would cost $1,000, -2 if $2,000, -3 if $4,000, -4 if $8,000 and so on. Failing the roll to build nano just wastes time; a *critical* failure produces a bad batch that seems good, but which will have dangerous or unusual side effects (GM's option).

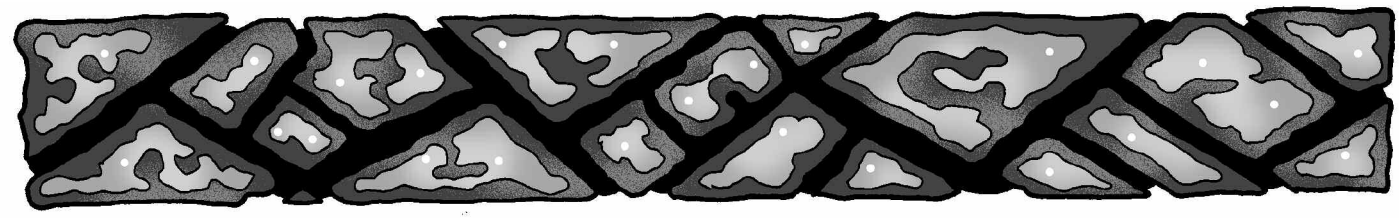
Types of Proteus Virus

Biotronic Virus (TL10)

Protein-based biotronic circuitry – biochips – are being used in more and more computers. Rumor has it that a few corporations have been creating living superhackers who can interface with these things directly, using nanoviruses that weave threads of DNA-based biotronic circuitry through their brains. Me, I don't believe it. We don't have the technology yet. Do we?

– Streethawk, alt.bio.samurai.upgrade

Statistics: Interface Jack (only with biotronic computers, -50%, 5 points); skill bonuses: Computer Operation +3 (only with biotronic computers, -50%, 1 point) and Computer



Hacking +3 (only with biotronic computers, -50%, 4 points); Enhanced Time Sense (45 points, only when interfaced with biotronic computers -75%, 12 points). *22 points.*

If using the ***GURPS Cyberpunk*** netrunning rules, effective phase length is *halved* when someone with this ability is netrunning while jacked into a biotronic computer.

Availability: $200,000 (and 4 days). LC 2.

Birth-Control Virus (TL10)

"If the Third World can't be bothered to control their own fertility, then I suppose we'll have to do it for them. Let's see: birth control implants, vasectomies, pills . . . but they're all so crude and time consuming, and then there's that problem of enforcement. How about isoimmunization, in which the mother's immune system attacks any fetuses, triggered after the onset of her first pregnancy? Spontaneous and usually undetectable early abortions; she'd probably never notice. One woman, one child. As for mass post-natal dissemination, a contagious proteus virus should do the job."

– Dr. Tse Chang, address to the Genetic Planning Council

Statistics: Sterile (after one child, -75%, -1 point).

Availability: $500 (and 2 days). LC 5.

Cosmetic Virus (TL10)

Bored with your current hair, skin or eye color? Need to alter your appearance in a hurry, or fix pattern baldness? Try McCoy AestheTech's viral cosmetics, and let RNA resequence your genes. Permanent, safe and undetectable, but reversible with a second dose! Each treatment produces a single, specific change. Also available: eyelash and fingernail modifications – your choice of length and color! Now available in handy tablet or ointment form – see your pharmacist today!

– McCoy AestheTech promotion

Statistics: The effects of a cosmetic virus are usually 0-point features, but viral dyes that cure or produce Albinism (-10 points) also exist. At TL11, exotic colors are also possible; e.g., blue skin, metallic nails or green hair. If unusual, these may count as Unnatural Features (-5 points). A cosmetic virus can also produce the same effects as a hair graft (p. 62).

Availability: $200 (and 1 day) for a batch of virus that can produce a single cosmetic change; e.g., turn eyes green or hair metallic pink. Multiply the cost and time by the number of features it produces. The occasional bad batch of viral dye may cause a piebald look, hair to fall out, and other minor nuisances. LC 6.

Genetic Surgery Nanovirus (TL10)

Any of the effects that can be produced by regular TL7-9 genetic surgery (pp. 75–77), such as gene therapy or metabolic reset, can be produced much more rapidly via a proteus nanovirus.

Statistics: Produces the same effects as regular genetic surgery.

Availability: Cost is 50% that of TL9 genetic surgery procedures or 25% that of TL7-8 genetic surgery. The virus will produce the changes in a number of days equal to *twice* the number of weeks of recovery required for actual genetic surgery. For example, a bone marrow upgrade that took 3 weeks would take only 6 days if using a nanovirus.

Methuselah Program (TL10)

Methuselah Inc. is pleased to offer its new life-extension process. A specialized proteus nanovirus injection can adjust or even reset the biological clock on your cells, modifying their ability to survive repeated replications. In partnership with Biotech Euphrates, our Forever Project staff is now working on nucleotide sequences that will hard-wire these modifications into unborn generations.

– Methuselah Inc. press release

"Their nanovirus is more expensive than those mythical anti-agathics you see in the sensies, but at least there's none of that nonsense about super-accelerated aging if you stop taking the youth drug. Of course, some of the companies that build bioroids use a similar process to build in a biological suicide clock to ensure good turnaround of new product. As soon as they start to get old, zap! Cells start to die, resulting in massive, multiple-organ cell failure, and they're dead in a few weeks. Bioroids get a little morbid about this, so few companies actually tell them their exact termination date."

– Dr. Sayyid Iqbal, interviewed on *Cyberia Beat*

Statistics: Halts aging (no aging rolls, and no growth if still growing) for about a year after undergoing the process. A perversion of this process can also be used to artificially shorten a lifespan, giving someone the disadvantage Self-Destruct, set to trigger after a predetermined point in their future.

Availability: $100,000 (and 4 weeks). LC 6.

Skin Transformation Virus (TL10)

So you're dating Lilith, huh? Isn't she that exotic dancer transform at Club Naga – the brunette with the red and gold scales?

– Streethawk, alt.bio.upgrade.samurai

Statistics: Select any one of the xeno-skin advantages listed on the *Xeno-Anatomy* table (p. 50).

Availability: Cost is (TL-8) × $20,000, and it takes (TL-8) weeks for the skin transformation to take effect, where "TL" is the minimum TL for gengineering that advantage. Thus, Fur (4 points, TL9) would take one week to grow and cost $20,000. Undergoing a skin transformation process is extremely uncomfortable. For the duration of the process, the subject will be at -2 DX and IQ (which affects skills) due to the constant itching and irritation as the fur or scales grow.

High-Biotech Fur (TL11)

Colonial Genetics' ShonTec/Mars division announces the arrival of viral-grown high-biotech fur, the ultimate in stylish thermoregulation! Features fully-retractable, sub-dermal, self-regenerating pseudohairs. Choose no or short fur for indoors or summer, but lengthen it as night begins to fall, then retract it as temperatures return to normal. Why bother with bulky thermosuits or even outmoded clothing? Perfect for outdoor conditions, and presently available in numerous attractive patterns, including tabby, mink, panda, leopard and tiger!

– Colonial Genetics press release

"My sources at ShonTec say they originally designed this feature as a post-natal upgrade for the 6th Mountain Division's bioroids, so it's probably pretty reliable. It's also available on their second-generation pleasure 'morphs. Have you seen those ads? 'Stay warm at night: Take a Kitsune to bed.'"

– Captain (ret.) Dana Martello, Marine Force Recon

Statistics: Thick Fur (variable length, +5%, 31 points). Length can voluntarily drop to that of normal Fur (two seconds), Very Thin Fur (four seconds) or completely retract (eight seconds), or vice versa. Remember, PD, DR and Temperature Tolerance vary depending on length. Very Thin Fur counts as light clothing.

Availability: $40,000 (and 2 weeks), LC 5. Side-effects of the high-biotech fur transformation are the same as for other skin transformations.

Neurovirus (TL11)

"I was having trouble getting on with my comp study, until I bought a Chinju-Gentek neurovirus and reconfigured my brain. Now I'm earning 20K a month in my summer job training AIs! Jump on the bio-logic bus with Chinju-Gentek, and take a ride to success."

– Chinju-Gentek commercial

Last year, Evolutionary Liberation Front terrorists hacked into the mainframe controlling the labeling on 2,000 vials of Chinju-Gentek RNA virus. 127 people who hoped to become musicians, many of them children, were instead transformed into mathematical geniuses, and 1,873 would-be Einsteins were left to sing the blues. The relationship between mathematical and musical talent was close enough that the quality-assurance software missed it. Bio-terrorism aside, this is obviously another example of the need for tighter controls in the civilian RNA-nanovirus sector."

– Tatiana Belenko, Genetic Regulatory Agency

A "neurovirus" is a specialized form of proteus virus, optimized for performing subtle changes in personality and mental structure by altering the connections between neurons and adjusting the neurochemical balance of the brain and body.

Statistics: A neurovirus can modify IQ up to the technological limits given for *Gengineered Attribute Modifiers* (p. 30), grant any of the advantages described under *Brain Modifications* (p. 32) and *Sleep-State Modifications* (p. 33), and add any of the genetic mental disadvantages from the *Mental Disadvantages* table (p. 53). It can also duplicate effects of Psychosurgery (p. 71) or Hotshotting (p. 71). Where they contradict, more recent neuroviruses overwrite previous ones.

Availability: $10,000 × (TL-7) per advantage or disadvantage, where "TL" is the minimum TL required for that procedure. Requires 1/2 day to take effect. LC 5.

Metamorphosis Virus (TL12)

"Captain's Log, 18-11-2447. It's been six days since our landing party was exposed to the nanovirus while exploring the ruined alien city. All remain in comas, within the cocoons their bodies have somehow secreted. Sonograms taken by Dr. Pretorious show significant anatomical changes, of which the most advanced are in Officer Melinda O'Reilly. Her legs have fused together into a tail, and wing buds are forming on her shoulder blades. I can no longer deny it; she is beginning to resemble the creatures depicted in the wall paintings we found. In an earlier log entry, I expressed my sadness at finding the aliens long dead, and being denied a chance at first contact. It appears I spoke too soon."

– Captain Zeke Morrigan, free trader *Antares*

A metamorphosis nanovirus is a highly advanced proteus virus. Like a proteus virus, it can resequence DNA, switch genes on or off, and take over cell nuclei, replacing entire genomes.

Unlike more primitive proteus viruses, it can also actively alter the gross structure of existing cells, using physical or chemical means to simultaneously

herd cells around the body, kill off existing ones, and force new ones to grow. This allows it to break down or build up connective tissue and bone. Using a metamorphosis virus, new organs can be grown *within* the body, existing organs and limbs can be transformed, and new limbs and appendages can be grown. A metamorphosis can even reduce body mass (leaving a gooey puddle of unused cells after the change).

In game terms, a metamorphosis virus effectively allows the type of human genetic engineering described in Chapter 2 to be performed on a living person rather than an egg cell. The virus is described as adding or removing a specific set of attribute modifiers, advantages, disadvantages and features – a "metamorphosis template." Select from those modifications that are possible via germline gengineering (Chapter 2) or surgery (Chapter 3). The time and cost of a metamorphosis virus depend on its complexity:

Time: This is (TL-8) days *per advantage, disadvantage or feature* added or removed, where "TL" is the minimum TL required to produce that change through gengineering or surgery. For this calculation only, treat any TL below 9 as TL9. Purely cosmetic traits that are part of an advantage or disadvantage don't count; otherwise, they count as a single, TL9 feature.

For example, a "cat-girl nanovirus" might have seven traits which require up to TL9 (e.g., Acute Hearing, Beautiful Appearance, Claws, Fur, Perfect Balance, a male-to-female sex change and transgenic cat features) and one that needs TL10 (e.g., DX+4). It would require [(9 - 8) × 7] + (10 - 8) = 9 days. Note that in practice, time may be reduced if the subject already has certain traits; e.g., if the cat-girl nanovirus were used on a woman, it would take only 8 days.

Cost: Calculate time as above, then multiply the number of days by $50,000 to get the cost. Thus, a virus that requires 9 days would cost $450,000.

TL: The basic TL of a metamorphosis virus is the *greater* of TL12 and that of the highest-TL modification that it adds or removes.

A "dose" of the virus can be delivered by injection or oral tablet. The rules for administration, HT rolls to resist and accidental infection used for other proteus viruses (p. 77) also apply to a metamorphosis virus. Any of the proteus virus options described on p. 82 can also be applied to it, altering the final cost, time and TL.

The Transformation

The nanovirus takes the indicated number of days to transform its subject. If the subject has a particular feature, it won't need to grow it, so reduce the transformation time accordingly (i.e., as if the virus didn't include that particular trait).

This also applies to attribute bonuses or penalties *that were created via gengineering* (as opposed to those native to a particular race). If the nanovirus adds a bonus and there's already a bonus, use the higher number; if the nanovirus adds a penalty and there's already a penalty, use the lower value; if the nanovirus adds a bonus where there's a penalty or vice versa, use the sum. Thus, if someone already has ST +2 as part of a gengineered racial template, then a nanovirus that gives ST +1 to ST +2 will have no effect, one that gives ST +3 will change his racial template from +2 to +3 (the character gains +1 ST), and one that gives ST -1 will alter his racial template from ST +2 to ST +1 (the character loses one point of ST).

While the metamorphosis is occurring, the patient may experience "nanofever" – itching, sudden sweats, hunger pangs or other odd sensations. Often, he sees odd shapes and patterns forming on his skin, or suddenly feels hungry, thirsty, hot or cold. This is distracting (-1 to IQ-related tasks during the entire process).

If the change is *radical,* defined as any process that takes more days than the nanovirus' TL, or which induces significant alterations in body shape or mass, the subject will fall into a coma after 1d days. This lasts for the remainder of the transformation. If this happens, the nanovirus will often secrete a caterpillar-like chrysalis from the patient's skin pores or other orifices, cocooning his body. When the transformation is complete, he will wake up and break out of it.

A metamorphosis nanovirus is not always safe. If the virus takes more days than the sum of the user's HT and the virus' TL, there is a chance that something will go wrong. Each day after this period, roll vs. the user's HT. Failure means some sort of accidental defect. Keep track of the number of failures. Each one inflicts -1d points worth of unintended disadvantages on the subject (GM's option; see *Gengineered Disadvantages,* p. 51, for a list of suitable possibilities). For example, failing three HT rolls would inflict -3d points of disadvantages.

Any critical failure means the subject dies – often very messily, as the patient transforms into a mass of cancer cells, is cooked in his own blood by excess heat from over-worked nanomachines or whatever.

Cybernetics or biomod implants that would be incompatible with the new form are excreted from the body or result in death or injury to the subject – details are up to the GM.

Sample Metamorphosis Transformations

Practically any transformation is possible with the aid of a metamorphosis nanovirus – for instance, it could turn a human into any of the variant races described in Chapter 2, make him into an alien, transform an alien into a human, or give someone any of the biomod surgeries or transplants in this chapter. This section provides additional examples of complex anatomical modifications that might be produced through metamorphosis.

The time listed for metamorphosis transformations assumes that the subject does not have any of the traits that the nanovirus produces.

Aquaskin (TL12)

Who needs a breather, wetsuit or clumsy artificial gill? Glide like a dolphin through the blue infinity while clad in GenTec Pacifica's Aquaskin, a smooth, high-biotech epidermal graft derived from marine mammal DNA. The skin is modified to selectively absorb and filter oxygen into the blood, bypassing the lungs and acting as a full-body gill. Available in several elegant shades of gray, brown and black.

– GenTec Pacifica promotion

Statistics: Amphibious (10 points) and Gills (10 points). *20 points.*

The smooth, monochrome skin and webbed fingers and toes may count as an Unnatural Feature (-5 points).

Availability: $150,000 (and 3 days). LC 5.

Chloramorphosis (TL12)

The green-skinned woman lay naked in the forest clearing, as if basking in the warm, noonday sun. I walked over and knelt beside her. If she was breathing, I couldn't tell. An ant walked across her face. She didn't react. I looked closer. Fine tendrils connected her body to the soil. She was rooting.

– Derin Skay, *Life Among the Dryads*

Statistics: Decreased Life Support (breathe carbon dioxide rather than oxygen when sleeping, 10 points), Deep Sleeper (5 points), Dependency (lie in fertile soil and sunbathe for at least eight hours; common, daily, -15 points), Doesn't Eat or Drink (10 points), green skin (racial feature, 0 points). *10 points.*

Availability: $400,000 (and 8 days). LC 5.

Hermaphromorphic Surgery (TL12)

Gender is obsolete with Matsai's latest bioengineered marvel. Creation of a fleet of sphincters, voluntary muscles and hormone pumps allows fully functional sex-switching in a matter of hours, as well as full fertility control.

– Matsai Corporation advertisement

Word of warning: If you become pregnant in female mode, you'll automatically switch back and be locked into female morphology about a week into the pregnancy unless you voluntarily choose to reabsorb the fetus, like I did.

– Chance Mackintosh, *Posthuman Consumer Review*

Statistics: Hermaphromorph (2 points) plus Reproductive Control (2 points). *4 points.*

Availability: $150,000 (and 3 days). LC 5.

Skeletal Strengthening (TL12)

"Tisephone Logos, if you closely look at the image produced by my T-ray scanner, you will clearly see the changes the nanosurgeons have produced in your body. Note the semi-fullerine skeletal structure and extra muscle attachment flanges, while the dark shading is the denser bone tissue. None of this will be visible unless your skeleton is physically examined or scanned, although you will notice a minor gain in mass due to the heavier structural tissues you now possess."

– Medical biocomputer Raphael-3000

Statistics: Extra Encumbrance (5 points) and Extra Hit Points +9 (45 points). *50 points.*

Skeletal strengthening increases actual body weight by 10% without increasing height or apparent bulk. The redesigned bone structure will also be noticeable on medical scanners, and by any doctor trying to set a broken bone. Skeletal strengthening does not increase ST. However, if someone has skeletal strengthening, then muscle reinforcement or muscle grafting can add double the usual amount of ST for their TL, since the biomod skeleton can support it. The effects are cumulative with bone stimulation (p. 74).

Availability: $250,000 (and 5 days). LC 5.

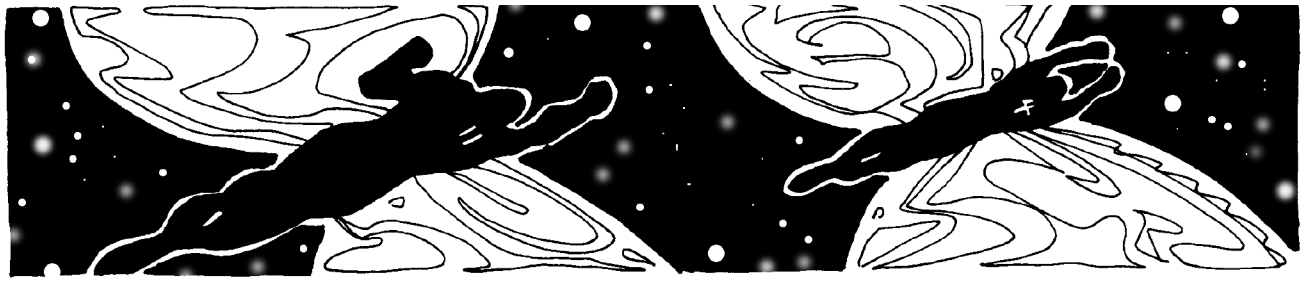
Smart Cardiovascular Net (TL12)

Next, the nanites construct smart, switchable arterial bypass networks to allow blood flow to be rapidly shut off to traumatized areas. As high-gravity accelerations cause blackouts when the blood pools in the lower body rather than reaching the brain, the arteries feeding the lower body have been redesigned to react to g-forces by pinching off blood flow to legs and abdomen while enhancing it to the brain. The same modification also produces faster recovery from unconsciousness.

– from FM-592, *Military Biomedical Enhancement*

"This is one thing those Marine jar-heads don't get. When I joined the Navy, I knew I'd get a neural jack – but I never figured becoming top gun would mean being dumped in a vat of nanosurgeons, dismantled and rebuilt. There's rumors that the spacekorps are working on bioroids ***born*** *with these things."*

– Lt. Majid Asad, VF-17, USSN



Statistics: Acceleration Tolerance (+5 HT bonus from it may also be applied to HT rolls to stop bleeding, +40%, 14 points) and Recovery (10 points). *24 points.*

Availability: $150,000 (and 3 days). LC 5.

Solarskin (TL13)

Freedom is the gift our Icarus-type symbiotic solarskin gives when you merge with Avatar Klusterkorp's gengineered ecosuit to become a true spacedapted form. Features closed-ecosystem waste-product recycling, solar wings and vacuum-sealed skin designed for protection against ultraviolet radiation.

– Avatar Klusterkorp advertisement

Naked, space-black dolls with enormous pseudo-wings, drifting through the vacuum on light pressure like dark angels: Avatar's latest vision of humanity, I guess. The one disadvantage is that you croak in a gravity field. You aren't anaerobic, though, so you can hang with your buddies inside the null-G section of a ship or station when you aren't "breathing vacuum." At least they designed it so you can fold up your solar sail when you don't need it – makes a hump on your back.

– Copernicus Jones, *Beyond Pluto*

Statistics: Flight (Requires Low Gravity: 0 G, -50%; Space Acceleration: 0.001 g, +5%; 22 points), Vacuum Support (40 points), Weakness: 0.05 g or higher gravity field, very common, 1d/minute (-60 points). *2 points.*

Availability: $500,000 (and 10 days). LC 5.

Proteus Virus Options

There are lots of ways that the basic proteus virus technology can be modified.

Accelerated Nanovirus (TL12)

"You mean I'm going have to wait ***days or months*** *for the nanovirus to grow my new face and improved heart? I got tickets to go skiing on Nix Olympica two weeks from now – but I can't go like this – I'm not in shape! What the fooz am I going to do?!"*

"Well, if you're that desperate, there's a black clinic that might be able to help you . . ."

– Dr. Lucien Locke, *Nanovirus for Dummies*

A nanovirus normally takes it slow and easy, because herding all those cells around and forcing growth is a major strain on a living being's metabolism. It doesn't have to be this slow.

At *double cost,* and a minimum TL12, an accelerated proteus nanovirus is available. An accelerated nanovirus takes *hours* instead of *days.* For example, if it normally took two days, the accelerated virus would do it in two hours. At TL15+, it may be even quicker, taking as many *minutes* as days.

If using *any* proteus virus, the accelerated growth process is stressful. The user will experience "nanofever" symptoms, as described for metamorphosis virus (p. 80). In addition, the user will suffer one point of fatigue each hour, until he passes out (he'll be unable to rest to regain this until after the virus has run its course).

If using a metamorphosis virus, it's often *dangerous* as well. Use the same rules for side effects (p. 80) as for a normal metamorphosis virus, but occurring if the virus takes more *hours* (rather than days) than (HT+TL-5). In addition, HT rolls to avoid suffering side effects are made at HT-3 rather than HT. Get too ambitious, and there's a good chance of a messy death.

Clinical Metamorphosis

"Uh – a messy death? 'Scuse me, Dr. Luce, I'm outta here. Isn't there a way the virus can grow a new part safely?"

"It isn't the virus that doing the growing, livewire; it's directing things. It's your cells that are doing the work. Remember, it's got to keep you alive. Imagine trying to do repairs on a car while the engine is running – heck, while you're still driving the thing around."

"Okay, okay – so why not stop the engine first? Or do the work from outside the car – I mean, the body?"

"Ooh, good one. Let's try it."

– Dr. Lucien Locke, *Nanovirus for Dummies*

A metamorphosis nanovirus can work a lot faster if it has help from outside. This is *clinical metamorphosis.* First, the patient is placed in a life-support environment, usually a growth tank, automed or (at TL13+) a chrysalis machine (p. 23).

Next, the patient is put into a state of complete bio-stasis, similar to suspended animation. A solution of specialized nanomachines is pumped into the tank with him. Some of these "nanobots" may be similar to a nanovirus, while others might be actual robots, either autonomous models or guided externally by a controlling computer, perhaps using acoustic pulses. These nanomachines are in charge of keeping the subject alive and speeding up the transformation by working both internally and externally.

Once the patient is in bio-stasis, more radical nanosurgical procedures can be used. If body mass is to be altered, intravenous tubes may be attached to the body and the necessary materials carted in or out by transport nano. Some tubes, made of nano-active material, may penetrate directly into the patient's body without breaking the skin. In radical transformations, the patient may actually be dismantled on the cellular level, turning him into a loose "puddle" of cells, then reassembled.

The process takes the same amount of time as an accelerated nanovirus – or half the time, if using a chrysalis machine – but it's completely safe (assuming no sabotage and no glitches in building and programming the nano). After the operation is over, the nanomachines will break up; their debris leaves the body via sweat or excretion. However, while it may be safe, this process isn't cheap: in *addition* to the usual price quoted for metamorphosis nanovirus, the life-support system and specialized nano used cost a minimum of $3,000 a day.

Other Proteus Virus Options

"Hey, Doctor Luce – this proteus nanovirus stuff – isn't it supposed to, you know, go out of control infecting and transforming everyone, and like that?"

"Of course not. Not unless you design it to. Here's how."

– Dr. Lucien Locke, *Nanovirus for Dummies*

Various options are available to change the way in which a particular nanovirus works. Unless noted, these may be applied to all procedures that use proteus virus, including metamorphosis virus. These will modify the price and tech level of the nanovirus, as shown in parentheses.

Note that a change in TL also has an indirect effect on price. For example, if a neurovirus is normally available at TL11, but is modified with the Plague option, then it is TL12; therefore, the price of that particular neurovirus would be halved at TL13 and again at TL14, rather than at TL12 and again at TL13.

Aerosol (10 times price): The nanovirus doesn't require injection. It can be used in a chemical warhead or aerosol spray. It uses the normal rules for biochemical weapons, and affects anyone who breathes it and fails a HT-6 roll. At TL+2, it may be a contact agent, penetrating the skin of anyone exposed on a HT-3 roll, or HT-6 if also breathed. An aerosol can will spray 1 dose at a time and holds five; 10 doses fill a chemical grenade, 30 fill a mortar shell. Halve LC (round down).

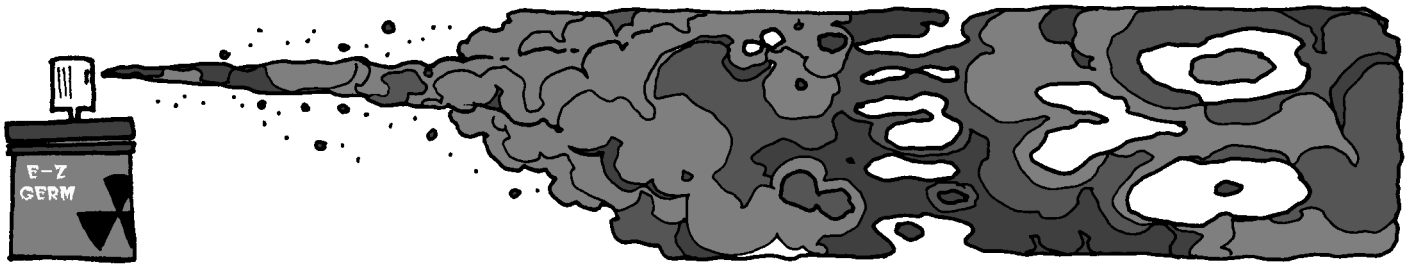
Delayed: The nanovirus is designed with a *time delay*. Instead of taking effect within a few minutes of infection, it remains dormant for a pre-set time period after infecting someone – anything from hours to years. This option has no effect on cost or TL, but the dormancy period must be chosen when that particular batch is designed.

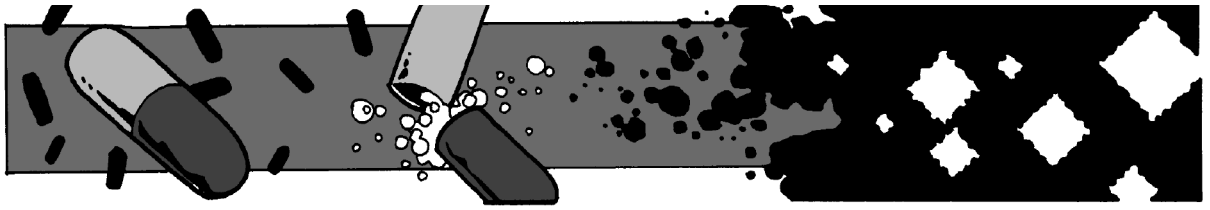
Heredity-Changing (TL-1): The nanovirus has *no effect* on the person it transforms – no twinges, sweats, coma or biomodification! However, it does alter genetic heredity, and the effects will be passed on to the subject's children. Since children have genes from both parents, inheriting virus-induced traits is much more likely if both parents have been infected by the nanovirus.

Inorganic (TL+1): The "virus" is composed of inorganic nanobots rather than biological machines. HT rolls to resist infection are made at a -2 penalty. Panimmunity, Disease-Resistant, Immunity to Disease and similar measures intended to defeat biological pathogens have *no effect* against it!

Plague (TL+1, 10 times price, or 100 times price if Inorganic): The virus can spread through skin contact and via breathing infected air. Anyone in direct skin-to-skin contact with a person who has been infected but not yet transformed can catch it on a HT-3 roll, or HT-6 if they exchange bodily fluids. For close proximity, use the rules from the *Contagion* sidebar, p. B133. Plagues are LC 0.

Random Metamorphosis (TL+2, special price): This has a semi-random series of effects on different subjects. It may give one person an exotic biomod, transform another into a different form, change a third person's sex, and so on. The GM should decide what percentage of victims suffer what type of effects,





whether there are any other side effects, and the maximum possible character points of change. Cost is up to the GM, but should be based on the *maximum number* of points that can potentially be changed. The *Wild Cards* shared world series (edited by George R.R. Martin) features a good example of such a virus.

Species-Crossing (TL+1, 10 times price *unless* Inorganic, then double price): Nanoviruses are generally effective only on a single species (and any variant races thereof) or a few closely-related ones – this is more a matter of programming in the case of inorganic nano. A virus that works on humans won't affect cats or dragons, for instance. This modification makes it pan-specific, capable of affecting multiple species provided they share the same basic biochemistry. Thus, a nanovirus designed to affect terrestrial life probably won't work on aliens, unless there's a good reason (e.g., if by sheer coincidence or design, we are amazingly genetically similar to them).

Target-Specific: A nanovirus can be designed to target specific characteristics; see *Target-Seeking Pathogens* (p. 89) for possible designs. A Plague may still be target-specific – people other than the target(s) will become carriers if they fail HT rolls, but suffer no other effects. This option has no effect on cost or TL.

Temporary: A *neurovirus* (p. 79) can be designed to produce only temporary effects by interfering with neurochemistry and hormonal balances rather than altering the structure of the brain. The effect will last for a number of hours equal to twice the amount the initial HT roll to resist was failed by (maximum one day). This sort of nanovirus is often used as a form of brainwashing or biochemical weapon. This option has no effect on cost or TL.

Xeno-Species Crossing (TL+2, 20 times price, Inorganic *only*): Capable of crossing between *extremely* different forms of life, such as terrestrial and alien life forms. Xeno-Species Crossing nanoviruses may still not work if the aliens are *very* alien; e.g., a virus designed to work on carbon-based life wouldn't affect silicon-based "living rocks." Given the (probable) drastic differences expected between human and alien life, a Xeno-Species Crossing nanovirus is more cinematic than realistic, but is nevertheless very common in science fiction.

Nanowarfare

The ability to create plague proteus viruses raises the spectre of exotic nanoplagues that transform rather than kill. For example, imagine spreading one that turned humans into compliant sex bioroids (like the Eros, p. 37). The threat of proteus plagues is somewhat lessened by the availability of sophisticated Panimmunity treatments, although these are ineffective against inorganic nanoviruses. However, humans don't have to be the target – imagine the havoc that even a "benign" intelligence-boosting neurovirus could cause if a species of pets, farm animals or wild animals became more intelligent! In fact, targeting nanoplagues at animals may be a viable surprise attack strategy, if humans have gengineered defenses.

Nano-Symbiotes

Symbiotic, pseudo-living nanomachines or genemod proteus cells can be introduced into the body, usually by injection. Instead of being used to build or alter something, they take up housekeeping.

The process of administering nano-symbiotes is identical to that for proteus virus: an injection or tablet – ideally, one that is matched to the person's metabolism. There are no side effects, since they don't alter the body, but simply exist within it. Here are few possible examples of nano-symbiotes:

Panimmunity (TL9)

Panimmunity injections contain artificial organisms, tailor-made for each individual. They recognize friendly cells, and attack others. Panimmunity is permanent.

Statistics and Availability: Depend on the bioengineering techniques of the society:

Level 1 Panimmunity (TL9): Gives +3 to HT to resist any disease. $1,000. LC 6. *2 points.*

Level 2 Panimmunity (TL10): Gives +8 HT to resist *any* disease. If this is not universal, cost is $5,000. Citizens in TL12 societies may receive Level 2 panimmunity free through government or corporate health plans. LC 6. *5 points.*

Level 3 (Total) Panimmunity (TL12+): Gives the recipient the equivalent of the Immunity to Disease advantage, with no minimum HT required. It costs $20,000 – although it might be provided free in organizations like the Survey Service. LC 6. *10 points.*

Blood Cops (TL12)

In my darker moments, I feel my bloodstream has turned into an arms race. They told me this is like Panimmunity 3 but more expensive: Inject a few trillion gengineered macrophage cells into your body, and these "active shields" will hunt down and dismantle anything that looks threateningly pathogenic or toxic before it can do much in the way of damage. It seems to have worked – I haven't aged or gotten sick since the procedure. Considering some of the places I've been, this is surely a miracle.

– Tisephone Logos, >warangel>heavenweb>solnet

Statistics: Immunity to Disease (10 points), Immunity to Poison (15 points) and Longevity (5 points). Costs 30 points.

Availability: $30,000, LC 6.

Cell Surgeons (TL13)

Hey, more nanoguys! These are programmed with details of your anatomy, and form a distributed, multicellular neural-net throughout the body. Most of the time, they just drift around, powered by your bloodstream. But when you get hurt, they'll shift into high gear and start fixing things, herding cells into place with tiny manipulators or sending signals that stimulate regrowth, while clearing away damaged tissue before it can get infected. These symbiotic cell-sized nanocritters let you heal real fast, but you sweat like the dickens, and afterwards you'll need to eat like a horse.

– Dr. Lucien Locke, *Symbiotes for Success!*

Statistics: Fast Regeneration (Costs Fatigue: 1 point/minute, -5%; Nuisance Effect: sweat heavily for -1 reaction, -5%; regaining any fatigue lost this way requires hearty meal, -10%; 40 points) plus Regrowth (small extremities only, -50%, 20points). *60 points.*

Availability: $60,000, LC 6.

Cell Communion (TL12/13)

I know why the NSA never caught them. Why the wiretaps and the laser mikes found nothing. I know the truth, because I borrowed Doctor Avery's scanning, tunneling microscope and used it on the sample. That's how I figured it all out – how the UFO people, the Men in Black and the True Illuminati communicate. It's their cells that are talking. Not talking exactly. Hormones? This is much more sophisticated, doctor. Not just emotions. More like images, concepts, memories, all at once. It's exchanged by sweat, saliva, blood, when they shake hands, touch, kiss. Don't you get it? Can't you see? They can conspire in crowds, in broad daylight!

– Statement by Walter Jorgenson, BSc in molecular biology, now a patient at Kingston Psychiatric Hospital

Statistics and Availability: Depend on the level of cell communion symbiosis:

Surface Communion (TL12) is Secret Communication (Touch Only, -20%, 16 points). $32,000, LC 5. *16 points.*

Deep Communion (TL13) is Mindshare: Racial Memory (40 points), Intelligent Drone (25 points), Touch Only (-15 points), 10-99 drones (0 points). $100,000, LC 4. *50 points.*

GMs should adjust the point cost, depending on how many have this ability, which determines the number of drones (see p. CI61).

Note that cell communion only allows communication with someone else who has the symbiotes. Some types of cell communion are actually contagious – the communion can spread out from the infected individual's body. Just buy this as a proteus nanovirus plague (p. 83) that grants these advantages.

4 MAN'S BEST FRIENDS

And God said, Let us make man in our image, after our likeness: and let them have dominion over the fish of the sea, and over the fowl of the air, and over the cattle, and over all the earth, and over every creeping thing that creepeth upon the earth.

– Genesis 1:26

Human gengineering is controversial, but the modification of plants and animals is much less so. We've been doing it for millennia; genetic engineering just lets us do it more rapidly.

Gengineered Microbes

Microbes range from simple bacteria to more complex algae and fungi (such as yeasts and molds). They are living chemical factories, taking in specific raw materials and converting them into the proteins their metabolisms require.

The advantage of gengineering microbes is that their simplicity and short generation length enable projects to proceed on a scale of months rather than years. Once microbial products have been developed, industrial biotech processes enable them to be cultured in giant fermentation vats that can hold thousands of gallons. With the right nutrients, such a *biomass* can grow very quickly, increasing its total mass eightfold in an hour!

Microbes at Work

For thousands of years, people have used microbes to manufacture products such as beer, bread and cheese. Beginning in the mid-19th century (TL5), and continuing into the 20th century (TL6-7), scientific techniques were applied to the study of microbes to find natural strains that performed new tasks or did old ones better. In this way, microbes usable in improved food and beverage products, industrial chemicals and medicine (see *Antibiotics,* p. 92) were produced, most notably penicillin.

Late-20th century (TL7) advances in biotechnology have largely relied upon gengineering specialized microbes, using the techniques of gene cloning and "protein farming" described in Chapter 1 (see *Gene Cloning,* p. 8). With genetic engineering, organisms can produce or extract a wider range of products, ranging from drugs and fuel to industrial chemicals.

Fermentation industries, like brewing and the manufacture of bread, cheese, yogurt and soy sauce, rely on the action of microbes such as yeasts, fungi and bacteria. Much of the late-TL7 industrial biotech effort – especially in Japan – has been devoted to the task of finding and mass producing fermentation enzymes or genemod microbes to make the process more efficient or the product more attractive or flavorful

For microbes to thrive, they need nutrients (such as sugars) for growth, as well as a carefully-regulated pH (acid) balance. Some microbes also require a narrow range of temperatures; because the temperature within a vat can change as the amount of biomass increases, most TL7+ fermentation vats possess sophisticated temperature-regulating equipment. As the optimum combination of temperature, acidity and nutrients varies from species to species, and the right or wrong choice can greatly affect yields, experimenting to find the correct vat environment is a major element in industrial biotech research.

Exotic Industrial Bacteria (TL7/8)

Not all "working bacteria" are involved in fermentation or protein farming. There are bacterial species which are naturally capable of metabolizing metals or chemical waste, are resistant to heat (even living in ocean vents) or are anaerobic (don't require oxygen). These have various applications, such as:

Fuel Production

Some bacteria or *archaea* (p. 7) can produce methane gas. These could be used as a renewable energy resource and source of industrial chemicals. Natural bacteria capable of performing these activities are in limited use today. At TL8+, gengineered bacteria capable of much higher performance will be introduced.

Mining and Refining

Bacteria exist whose proteins can bind to and concentrate traces of metals from mine shafts, industrial wastes or sea water. The biomass can then be collected and refined. More complex (TL8) versions of these bacteria can excrete the minerals themselves, reducing the cost of downstream processing.

Pollution Control

Bacteria can be designed to break down plastics that have been properly treated, while those that metabolize hydrocarbon molecules can mop up oil spills. Often, bacteria of this sort don't even have to be genetically engineered. Instead, biotechnicians look for sites that have been contaminated for years by (for example) an oil spill, and then isolate the microorganisms that are thriving there. These may also be designed as weapons – see *Anti-Material Bacteria* (p. 90).

Terraforming Microorganisms (TL9)

Gengineered algae and bacteria will play a major role in any planetary engineering program. For example, in a Mars terraforming project, they would be released a decade or so after ice asteroid or comet strikes had provided water, but before organisms are added to the ecosystem. Hardy anaerobic bacteria would perform the critical task of releasing nitrogen locked beneath the planetary surface. Within a decade or two, they would be followed up by gengineered lichen and fungi. In a generation or two (25-50 years), the soil may be fertile enough that simple oxygen-producing plants can be introduced.

Germ Warfare

Not all microbes are busy little workers. Pathogenic microorganisms, such as bacteria and viruses, have a long history as weapons. Even before people had an inkling of the germ theory of disease, medieval siege engines lobbed disease-ridden carcasses into fortified cities. During the conquest of North America, smallpox-laden blankets may have been employed to decimate Native American tribes. In the 1930s and 40s, Japan

experimented with the use of plague in its conflict with China.

Modern science has made it possible to prepare stockpiles of actual germ cultures, and to arm spray tanks, bombs and missile warheads with disease-carrying bacterial spores. However, science has also alerted us to the dangers of these weapons. No weapon is more uncontrollable than a plague, capable of crossing borders with impunity to scythe down friend and foe alike. While limited numbers of people can be given preventive treatments in advance (perhaps even secretly, disguised as a routine flu vaccine), germs also have a distressing tendency to mutate.

Society bans weapons when they are simultaneously difficult to control, imprecise in their effects and capable of exciting moral outrage. Germ warfare falls into all three categories, and so international efforts to outlaw microbiological weapons have been relatively successful. While stocks of bioweapons existed at the height of the Cold War, most nations at least claim to have destroyed their germ-warfare arsenals today – although several are suspected of having secret bioweapons programs. Note that some cultures have been preserved so that they can be studied for disease prevention and treatment.

Current (1997) fears of biological weapons are centered on their use by terrorists, such as the Aum Shinrikyo cult, which released nerve gas in Tokyo's subways in 1995 and which was also developing biological weapons, and by desperate "outlaw regimes," such as Iraq under Saddam Hussein.

Unfortunately for human survival, the international consensus that has banned bioweapons could come to an end some time in the next century. Biological weapons are far cheaper than nuclear weapons; with the end of the Cold War leaving the U.S.A. as the only global superpower, some nations may feel that germ warfare offers an affordable counter to U.S. nuclear might. Another culprit is genetic engineering, which threatens to make possible "smart" microbiological weapons that are far more *controllable* than nature's plagues. Soldiers and politicians might find such tools too useful to be suppressed.

Fortunately, the mechanics of epidemics make it difficult to kill off an entire natural species with a single disease. A germ that is "too successful" and kills off all exposed targets leaves behind no reservoir of disease organisms to infect isolated victims who escaped the initial outbreak. A disease that is less lethal will leave a population of survivors immune to it, lessening the disease's future impact. Deliberate or accidental germ warfare might kill off most – even 95% – of a particular species, but probably won't wipe it out entirely.

Popular Biological Agents

The most popular biological weapons are pathogenic bacteria and viruses. In addition, some types of bacteria can also be used to manufacture poisons (just like they can make useful proteins). An effective germ-warfare agent should be lethal, or at least incapacitating, and easily spread. If you can only catch the disease from sexual contact, for example, it is less dangerous than one that will contaminate an area and whose spores can be inhaled.

In general, bacteria are easier to work with than viruses and, because they can survive as spores outside a host and contaminate an area for long periods. On the other hand, viruses are harder to treat (being immune to antibiotics). Biotoxins are not contagious, but can be used to contaminate food or water supplies – the usual terrorist scenario is dumping a large dose into a city water plant.

Since germs are difficult to control as a weapon, it is often a good idea to choose a pathogen that can be treated (e.g., anthrax), as this gives you time to secretly prepare for the disease, while your target may be caught by surprise. Some favorite biological agents are listed below; ***GURPS Compendium II*** describes other diseases that could conceivably be used as bioagents – see pp. CII167-174.

Anthrax

This disease is caused by a bacterium (*Bacillus anthracis*); people can catch anthrax by touching or inhaling its spores. Use the *Illness* rules (p. B133), but with a -2 on HT rolls for contagion. Anthrax can contaminate an area for about 40 years before the sun and rain break it down. If the disease is caught, symptoms appear in two or three days, including coughing, shortness of breath, fever and vomiting, followed by internal and external bleeding lesions if the disease worsens. Use normal rules for "generic" diseases, but with a -3 to daily HT rolls. Anthrax has been cultured by several nations since WWII, and is easy to load into bomb and missile warheads. Vaccines exist, and antibiotics are effective against it.

Botulinum Toxin

An example of a biotoxin, this is a *poison* that is manufactured by a bacteria (*Clostridium botulinum*). It can be manufactured in fermentation vats, and may be a favorite of terrorists. As it isn't a germ, it is not contagious – but it is very lethal, and can be used to contaminate food or water supplies. If it enters the body (usually via contaminated food or water) it causes 4d damage after 2d hours. A HT roll halves damage; an antitoxin ($10) halves damage again. Each dose is $200. See also p. CII139.

Bubonic Plague

The "Black Death," caused by the bacterium *Yersinia pestis,* devastated Europe in the Middle Ages. Bubonic plague cultures exist in research labs around the world, making it relatively easy to acquire. The plague is spread by rat-borne fleas; a related disease, *pneumonic plague,* is spread by contact or airborne spores, making it more suitable for dispersal in warheads. See p. CII168 for details. Vaccines exist, and antibiotics are effective against it.

Ebola

An extremely lethal virus – although ebola Zaire is not as contagious as some "scare stories" have portrayed it to be, as it seems to spread to humans only through direct contact with blood, rather than through inhalation of viral particles. There is no chance of contagion if all contact with victims is avoided, but HT rolls are at -5 if in physical contact with a victim's blood or bodily fluids.

Symptoms occur 2-3 days after exposure, and include high fever, joint pain, delirium and destruction of internal tissue. Daily recovery rolls are made at -4, with critical failure meaning loss of 1 HT per *hour* until death, failure meaning 1d lost HT, success meaning loss of 2 HT, and critical success meaning loss of 1 HT, but the disease is thrown off. The disease requires a critical success or two consecutive successes to shake off. Loss of half of original HT means the disease affects the brain, causing Bad Temper (or Berserk, if already bad-tempered) and causing further failed HT rolls to result in -1 IQ as well. If HT drops below 1/4 normal, the victim also suffers Hemophilia and begins to bleed from bodily orifices. Death comes with convulsions, which can splatter blood around the immediate area. There is no known vaccine, and antibiotics are ineffective.

Influenza

The "flu" virus, in various strains. Influenza is spread by contact with infected individuals. A typical example uses the generic illness rules (p. B133). It is very infectious (an extra -1 on HT rolls to avoid catching it, unless *all* contact with victims was avoided), but treat it as a generic disease for symptoms and recovery rolls. Vaccines are available, but antibiotics are ineffective.

Rabbit Fever (Tularemia)

Believed to have been used in some germ-warfare programs, this resembles a mild form of bubonic plague. In nature, humans can catch it by eating infected rabbits, but the bacterium can be cultured so that contact with its spores causes infection. Treat it as a generic illness (p. B133) for contagion. If caught, symptoms appear in 3-5 days, including head and body aches, fever, ulcers and swollen glands. To recover, roll vs. HT each day, with failure causing the loss of 1 HT and success recovering 1 HT. Recovery of all HT *doesn't* end the disease; rather, it progresses until 2d+10 days have passed or a critical success is rolled. See also p. CII171.

Enhanced Germs (TL7)

This is the biowarfare nightmare scenario – the use of genetic engineering to produce an "improved" pathogen.

Treatment-Resistant Germs (late TL7): The simplest kind of gengineered germ warfare is to modify a virus or bacteria so that it does not respond to known vaccinations. While a new vaccine may be developed against it, it could be too late by the time it is ready.

Increased Infectivity (TL8): Designing a more infectious strain. A -1 or -2 on the HT roll for contagion (see *Contagion,* p. B133) is possible at TL8, a -3 or -4 at TL9+. The rapid onset of symptoms (in hours rather than days) may also be possible.

Species-Jumping (TL8): While some lethal germs harm multiple species, many diseases that are very lethal against certain animals have no effect on humans, and vice versa. In nature, this can change through mutation, allowing a virus or bacteria to "jump the species barrier." This might also be done artificially, so that a disease known to be a very efficient killer of monkeys, sheep or Alpha Centaurans (for example) could be altered into one that kills humans. Modifying terrestrial diseases to affect aliens (or vice versa) requires at least TL9; having live subjects to experiment on is usually necessary.

Tailored Lethality (TL8): Designing a more (or less) lethal strain. Ordinary illnesses work as described on p. B133, while highly lethal ones like ebola or bubonic plague allow recovery only on a critical success or consecutive normal successes, or do more damage. At TL8, modifications to recovery rolls (e.g., an extra -1 to -3) or to the severity of symptoms (e.g., doubling HT loss) are possible; at TL9+, more drastic modifications can take place (e.g., increasing the lethality of influenza to that of bubonic plague).

Vector Modifications (TL8): Some of the most lethal diseases (like AIDS or rabies) spread only through contact with bodily fluids. This means that they can be contained by taking the proper precautions. However, gengineering might be used to alter a particular agent so that it can be airborne – e.g., redesigning ebola so it can be spread by coughing, or carried by mosquitos, fleas and the like. Of course, this might not always be desirable, since it makes it much harder to control. This will modify the circumstances under which a contagion roll is required.

GMs should feel free to customize the illnesses in ***GURPS Compendium II*** and this chapter, as described above. ***GURPS Reign of Steel*** (pp. RS111-112) also gives examples of "improved," gengineered versions of influenza and ebola.

Target-Seeking Pathogens (TL8)

"Uh, Michelle – what's with the mask and gun? Have you gone Howard Hughes on me? Okay, I'll take off my clothes – hey, that spray stings! That's my best outfit! Don't burn it! What's going on?"

"It's the Russki-Yak, Tommy. They've sicked a smart superflu virus on me, tailored to my

genetic code. They don't know where I'm hiding, but it doesn't make a difference. Anyone in town could be a carrier – you, the dog, the landlady – it's not important, 'cause it won't do a thing to them. It has my name on it."

This genetic modification is one of the more exotic potential spin-offs of gengineering and genome mapping. With this know-how, a microorganism (most likely, a virus) might be modified so that it will only attack individuals who possess certain genetic markers.

At TL8, a virus can be modified so that it affects a fairly clear-cut set of genetic traits; e.g., blond hair, men only, women only. People possessing recessive genes may be vulnerable to target-seeking viruses without obviously exhibiting those traits.

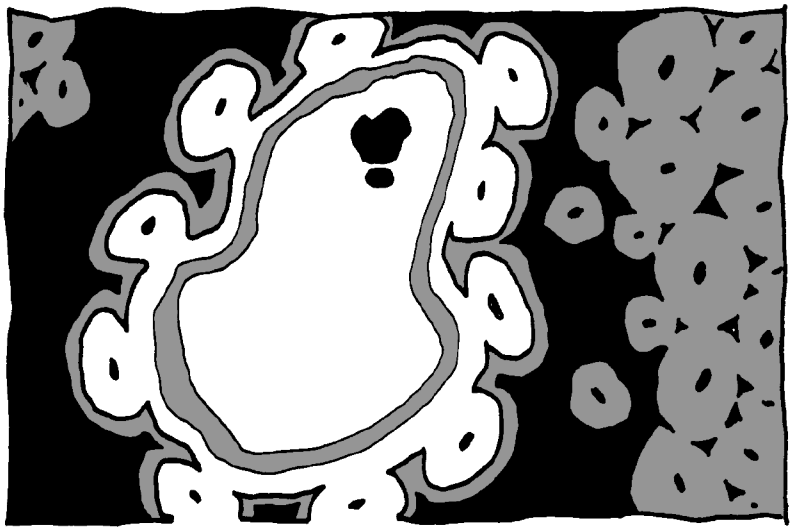
At TL9, a virus can be modified to attack individuals with more complex combinations of genetic traits – for example, those that make up a particular racial group, or even traits known to be common to a particular family.

At TL10, even more discretion is possible. A virus might be targeted specifically at an individual – it would affect him, or his clone or twin, but no one else.

At TL11+, target-seeking viruses can be a lot smarter, using biological nanomachines rather than simple engineered viruses; if the genome information is correct, they are reasonably foolproof.

"I didn't mean it! It was a mistake! How was I supposed to know the sequence I picked to target that Michelle woman was also found in the capo's wife and daughters?"
– Doc Hobo, street splicer

It is absolutely vital to have acquired accurate information on the genetics of the intended target group before the virus is created! The would-be viral warrior should exercise great care in specifying what traits the virus will target. For instance, suppose a white-supremacist terrorist group wants a virus that will target non-whites. Unfortunately for genetic Nazis, in all but the most isolated countries, there have been centuries of racial mixing. As a result, the virus will probably either kill a lot of the group's own members, or spare many of the people they want to affect, depending on how selective its designers made it. This is even true of "simple" targets like hair color, since very few phenotypes are governed by a single gene – a competently-designed virus intended to kill blonds will do that, but will also kill some non-blonds and leave some blonds alive.



New Germs

Even more frightening than simply tinkering with existing germs is the prospect of an entirely new "designer plague." This would probably be produced by extensive modification of an existing (even harmless) bacteria or virus, perhaps combining genetic material from multiple different organisms into one.

New germs should be designed using the guidelines on p. B133 or by modifying the various diseases described in ***Compendium II.*** The best way to "personalize" new diseases is to select disadvantages that occur in addition to HT loss, usually after 1/3, 1/2, 2/3 or 3/4 HT has been lost to that disease. Especially appropriate disadvantages include Blindness, Sterility or even Bad Smell (from rotting flesh). More exotic diseases might even cause mental disadvantages by attacking brain tissue.

Sample New Bacteria – Oedipus-5 (TL9)

This is a terrifying bacteriological weapon that attacks the nervous system and strips away neural sheathing. The bacterium also has a special affinity for attacking eye tissue. Oedipus-5 does not always kill, but survivors are often left uncoordinated and blind, posing additional problems for treatment.

Infection: Spreads normally, as described on p. B133.

Symptoms: These develop in 24 hours, and consist of blurred vision and dizziness. Loss of more than 1/3 HT causes -1 DX. Loss of more than 1/2 HT results in -2 DX, Bad Sight and the Total Klutz disadvantage (p. CI82). Loss of more than 2/3 HT causes -3 DX, and adds the Blindness and Confused (p. CI88) disadvantages; the eyes turn into weeping sores filled with pus, and the body shakes constantly.

Progress and Recovery: A HT-4 roll is required every day. A critical failure means loss of 1d+1 HT. A failed roll means loss of 1 HT. A success lets you regain 1 HT. Three consecutive regular successes, or a critical success, means the disease is shaken off. HT is recovered normally, but any disadvantages gained are permanent.

Treatment: Antibiotics have their normal effect, and Panimmunity will also provide a bonus. Neural and vision damage may be fixed by TL8+ fetal tissue and eye transplants, but the process requires major transplant operations, and will cost at least $2,000 per point of disadvantage that is to be repaired.

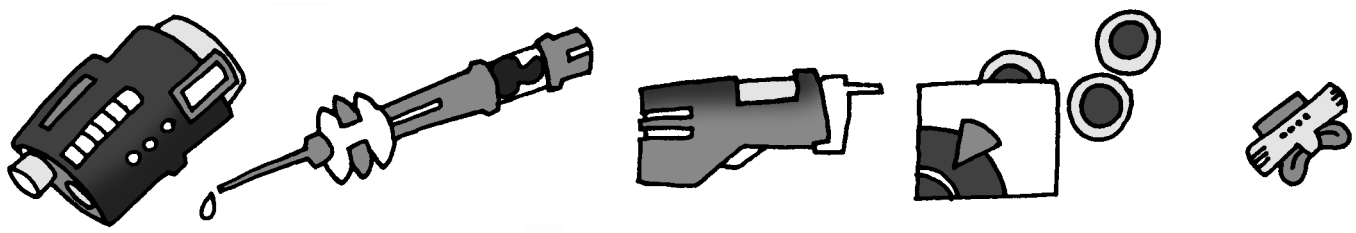
Anti-Material Bacteria

Halfway between killer germs and exotic industrial bacteria, these are microorganisms designed to attack nonliving things rather than animals or plants. Some types that are already under development (making them TL8) include:

Explosive-Eating Bacteria: Usually targeted at a specific chemical explosive; e.g., TNT, RDX, Plastex-B, et cetera. These will knock out explosive warheads and chemical propellants.

Petroleum-Eating Bacteria: Based on bacteria used to clean up oil spills, these are designed to eat hydrocarbon-based lubricants and fuels such as gasoline, diesel and jet fuel.

Rubber-Eating Bacteria: These could destroy tires, fuel lines, valves, boots, et cetera, disabling vulnerable equipment.



Other Types: At TL9+, more exotic types of bacteria (or nanomachines that work like bacteria) may become available that can rapidly degrade plastics, various biotech materials and even silicon chips. However, bacteria won't have much chance against metal, stone or most advanced composites and ceramics. Other types of microbes may also be used.

If equipment or supplies that are vulnerable to a particular anti-material bacteria are in an area that is contaminated, or come into contact with infected material, check for infection. Use the *Contagion* rules (p. B133) as guidelines to see if the bacteria infect particular material. Ignore modifiers for eating flesh, but "intimate contact" would be direct physical contact with contaminated material – e.g., topping off an uninfected fuel tank with contaminated gasoline, or spraying the bacteria directly into a mechanism. Instead of rolling against HT, use the TL+2 of the material the bacteria attacks, or its container, whichever is higher.

Generally, infected material will show initial signs of rot or contamination after 24 hours and become useless (eaten away, turned to goo, et cetera) within 48 hours. During this time, the bacteria can infect other material it contacts. A roll against NBC Warfare skill (p. CI151; biological sensors like bioscanners give bonuses) can detect contamination early enough to treat it (using disinfectant sprays, et cetera). A fully-airtight container or seal will protect against anti-material bacteria. In the case of sealed vehicles or bases, GMs can require occasional rolls vs. NBC Warfare skill, with a failure or indicating that some sort of mistake was made (e.g., a seal left open), which will allow a chance of contamination. Of course, saboteurs can always open up machinery and actually spray the bacteria into it directly!

In general, anti-material bacteria are devastating against unprepared targets (especially at TL7 or less) but will be of limited use against targets equipped with countermeasures, such as ultra-tech military forces. See also *Cleanup* (p. 127).

Purchasing Microorganisms

Natural bacterial or viral cultures (for existing germs) might be available on the black or open market. The open-market price for legitimate science labs is in the $100-$1,000 range. Only a few doses of any disease will be sold, since after the sale, it is relatively easy for anyone with a genetics lab to culture the disease extremely cheaply. For this reason, *gengineered* microorganisms with commercial or military value will often have sticker prices up to a thousand times higher, in order that some profit can be realized.

Lethal bioagents are usually LC -1 to 2, and black-market prices may be a hundred times higher per dose. If a production line is set up, prices may drop to about $10/dose. A pathogen whose purpose is relatively benign (e.g., one intended to get rid of a certain breed of dangerous animal or to kill off insect pests) may be LC 4 and available on the open market.

Any system for delivering drugs (hypos, needler rounds, et cetera) can carry biological weapons. A HT-4 roll is required to avoid contagion if injected or shot. Depending on the disease vector, bioweapons may also be delivered by insects (see p. 95) or other animal carriers. Bacterial spores or virus particles can be loaded into a chemical round such as a gas grenade or bomb and detonated to create a plague-ridden area, or put into ventilation systems, sprinkled on artifacts in tombs and so on. Usually, the number of doses to contaminate a given area of effect is R × (R-1)/3, where R is the desired radius in hexes.

Designing Gengineered Microorganisms

These use a simpler version of the system for gengineering humans. See *Designing Plants, Microorganisms and Insects* (p. 97).

Fighting Disease

What science produces, it can also cure – sometimes. In addition to chemical treatments, bioengineering has produced several methods of dealing with disease.

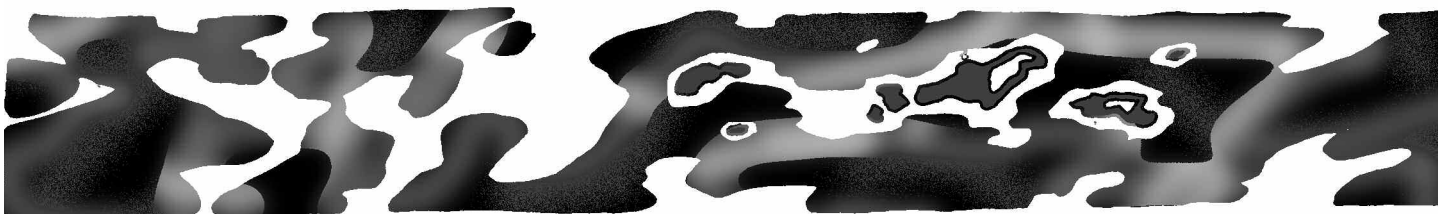
Vaccines (late TL5)

A *vaccine* is a suspension of dead or weakened disease-causing viral particles or bacteria. Injecting a vaccine ("inoculating") tricks the subject's immune system into producing defenses ready to fight off the real disease, should it appear.

The concept originated with Edward Jenner at the end of the 18th century and was developed by Louis Pasteur in the 19th, but only in the 20th century did vaccines become relatively cheap (prices average $20/shot, but can be as little as pennies per shot). Programs of mass-innoculation are responsible for the virtual extinction of several diseases, including smallpox. They have also *spread* a few diseases, when innoculations were performed with unsterilized needles.

With few exceptions (notably rabies), innoculation is only effective on someone who *has not yet caught that disease.* In game terms, a vaccine gives someone "Immunity to Disease" against one particular strain of pathogen – but as viruses are constantly mutating, new vaccines may need to be created (use the *New Invention* rules, p. B186).

Making a vaccine is tricky: If it is too weak, it won't provide immunity, while if it is not weakened enough, it may infect



the patient. This is especially important when dealing with very lethal diseases! One solution is *genetically engineered vaccines* (late TL7). These are made by splicing genes for a virus' outer protein coat (which is what the immune system recognizes) into bacteria. These are then cloned, and the harvested proteins used to make a vaccine. With no "real" virus particles, the vaccine is both strong and safe.

Antibiotics (TL6)

Antibiotics are substances derived from microorganisms, originally mold. While non-toxic to humans (except for a few people who are allergic to them), they kill other microbes, halting infection. Antibiotics are effective against bacteria and fungus infections, but are ineffective against viruses and some parasites (e.g., malaria). The first antibiotic was *penicillin,* discovered by Sir Alexander Fleming in 1929 and mass produced during World War II.

A typical antibiotic is effective against only one type of bacteria or fungus infection. It gives +4 to HT rolls when rolling to shake off whatever strain it was designed to fight, and +3 vs. closely-related strains. Broad-spectrum antibiotics are also available, and provide a +2 HT bonus against most terrestrial bacteria and fungus infections and +(1d-3) (minimum 0) vs. newly-encountered germs (record that bonus). A typical price for a course of antibiotics is $10 (halved at TL8), though types targeted against rare diseases may be more costly, in very short supply or still under development.

At TL10, the wonder drug *Genericillin* (p. UT99) becomes available. A single dose costs $100, and gives +4 to HT against most Terran diseases and +(1d-1) to HT against newly-encountered germs (again, record that bonus). These bonuses apply for the duration of the disease; there is no ongoing "course" of treatments.

Antibiotics were the wonder drugs of the mid-20th century, allowing doctors to treat diseases rather than just relieving symptoms. However, we now know that they are not a panacea. Under evolutionary pressure from antibiotics, many strains of bacteria that were vulnerable to them were killed off, while new strains have arisen (or mutated) that are far more resistant. In turn, pharmaceutical laboratories have subjected antibiotics to processes designed to alter and change them, in a constant struggle to produce superior disease-fighting weapons. GMs should decide if a particular disease is antibiotic-resistant; if so, antibiotics will provide half or no bonus (GM's option).

Enzyme-Blocking Medical Drugs (Late TL7)

Gengineered enzyme production and gene cloning allow the design of specialized drugs that work by blocking specific vital enzymes that a particular virus or bacteria needs to replicate. The key to successful enzyme-blocker design is to find an enzyme that is vital to the target virus or bacteria but which is not used by human metabolism. In a few cases, this may prove difficult. If so, the enzyme blockers may have some side effects – typically, each daily dose will also require a HT roll to avoid taking one point of damage, whether the enzyme-blocker succeeds or fails. Some enzyme blockers used to combat AIDS have this problem.

Enzyme blockers may either be targeted against a single species of virus or bacteria (e.g., influenza) or be broad-spectrum versions, designed to affect numerous common bacteria. Unlike a vaccine, a specific enzyme blocker is generally effective against mutant strains; a mutation is rarely drastic enough to alter the fundamental enzymes that a particular virus or bacteria uses.

A *specific* enzyme blocker, affecting *only* one microbe, gives a +8 to HT rolls to resist that particular illness; broad-spectrum agents give a +4. The effect is similar to that of an antibiotic, but is effective against viruses or parasites; HT bonuses are cumulative with antibiotics.

A typical course of enzyme-blocking drugs costs about $100 at TL7, $20 at TL8, $10 at TL9 or $5 at TL10+. Some (such as those used to treat AIDS) are far more expensive, costing this much per *day.*

Gengineered Plants

Billy Falkenburg stood by the fence post, his dog Ruff beside him. The fields of transgenic cotton stretched for acres, a brilliant orange cloud as far as the eye could see.

"Dad's farm's so dull," Billy muttered. "Good thing summer's almost over. I can't wait to get back to orbit."

"Me, too," Ruff growled.

Genetic engineering is poised to exert a revolutionary transformation on Earth's agriculture – in fact, it has already begun to do so. A variety of factors are lending impetus to these changes. Rapid population growth means we need to grow more food, which means either higher yields or finding ways to grow things in barren areas. Continuing environmental degradation means we need crops that can grow in areas where soil or water resources are depleted – or crops that don't deplete soil.

Some of the possible developments in gengineered plants are described below. No costs have been given, but as a general rule, the start-up costs for a genemod strain are several times higher than for ordinary seeds, but eventual yields will be much greater. In a commercial sense, this may favor corporate agribiz and rich-nation farmers, who can afford the latest gengineered crops and thus have a competitive advantage. On the other hand, if gengineering technology becomes widespread (likely at TL9+), even poor regions could make their own bioengineered crops.

Plant Cloning

Plants are exceedingly easy to clone compared to animals. From a biotech perspective, this means that if a *single plant* has been shown to be disease-free or unusually fertile, it can be rapidly cloned, making thousands of identical copies without the genetic variation introduced by simply using the seeds of that plant. A risk of doing this sort of thing to excess, though, is the reduction of overall genetic diversity, which might make a species more vulnerable to pests or disease.

Growth Times

The growth times listed for plants generally assume normal agricultural practices. If forced-growth tanks (p. 19) large enough to contain an adult plant of the desired size are used, the time required will drop to a flat 6 weeks.

Designing Gengineered Plants

These use a simpler version of the system for gengineering humans. See *Designing Plants, Microorganisms and Insects* (p. 97).

Adventures with Seeds

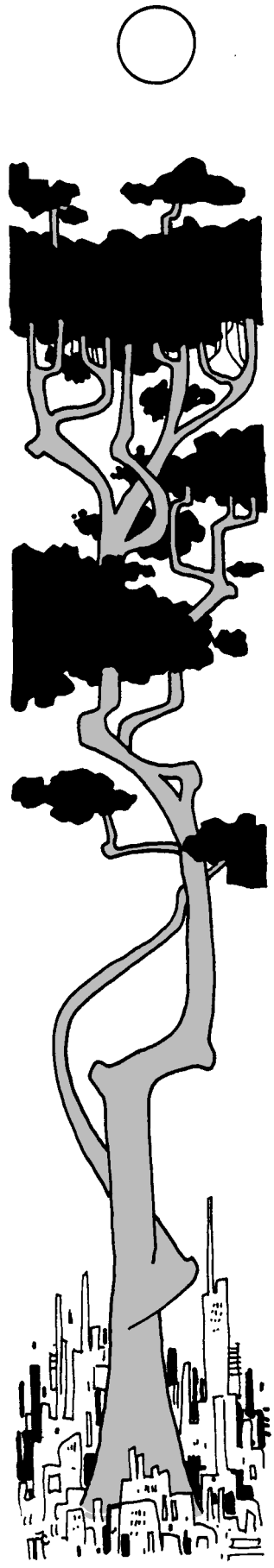
While genemod crops aren't as exciting as killer viruses or modified animals, they could easily figure into an adventure plot. A new species or strain of plant, or samples from an especially healthy or fertile plant that is destined for cloning, might be the target of industrial espionage or eco-sabotage, since it could be worth megabucks to an agribiz corporation . . . or be a matter of life or death for a famine-threatened region or struggling colony world. For an interesting take on this, the classic *Star Trek* episode *The Trouble With Tribbles* is well worth viewing.

Plant Modifications (Late TL7)

In the past, farmers and scientists have used eugenic procedures to produce crops with higher yields or faster growth rates. Gengineering will speed up these improvements, but it can also offer more exotic biomods. A number of these are listed below. These *can* be combined; e.g., plant-cloning of especially healthy, climate-adaptive, nif beefapples.

Disease-Resistant Plants (Late TL7)

Gengineers have already succeeded at introducing genes into several crop plants to make them tolerant of germs and fungi. At TL7-8 these are usually disease-specific, aimed at resisting common scourges. *Broad-spectrum disease resistance* (TL9) and *disease immunity* (TL10) may also be possible, allowing crops to be protected against unknown threats or even gengineered bioweapons.



Industrial Plants (Late TL7)

Researchers have already spliced bacteria that produce normally-expensive biodegradable plastic into fast-growing plants; with "plas-plants," it should be possible to harvest such environmentally-friendly plastics at a small fraction of their usual cost. In a similar vein, oilseed crops (like soy beans and rapeseed) are being gengineered to produce oils that can be used to make environmentally-friendly lubricants and detergents. At TL8+, there are numerous possibilities. How about two-year-growth, *barkless* trees for the wood and paper industry, or long-fiber, seedless cotton with the dye already gengineered in?

Market-Friendly Crops (Late TL7)

Food plants may be redesigned with the supermarket shelf in mind. Short-term possibilities include designer flavors, longer shelf life for fruit (adding genes designed to block enzymes that cause over-rapid ripening), tougher skin (to reduce bruising and allow mechanical picking), and antioxidants that would keep apples from going brown when exposed to air. At TL8+, shape may be modified: How about *square* fruit or vegetables, for easier packing?

Pest-Resistant Plants (Late TL7)

Insects lay waste to billions of dollars worth of crops every year, or force the use of expensive (and sometimes environmentally-damaging) chemical pesticides. By splicing in genes from a bacteria or virus that makes a particular insect sick (but which has no effect on other species), plants can have their own, built-in insecticides, targeted against their natural enemies. This has already been done with some tomato, cotton and potato plants, making them resistant to particular kind of caterpillar.

Pharm Plants (Late TL7)

Like bacteria, transgenic plants can be gengineered to yield medically-useful proteins (usually, a certain amount of processing is required). Already, trials are underway with plants designed to produce serum for treating burn victims. At TL8+, plants may produce designer proteins that can be used to manufacture various "wonder drugs."

Drought-Resistant Crops (TL8)

Vast tracts of land are presently useless for agriculture due to insufficient water or high salinity. Disputes over the diversion of rivers for irrigation purposes may lead to war in water-poor regions, such as the Middle East. One solution may be to make the deserts bloom without extra irrigation. The *osm* genes (which regulate *osmosis,* the loss or gain of water in plant cells) may be tinkered with, based on what is known of

species that survive in harsh climates. The result may be strains of "drought-resistant" crops, or crops which are adapted to a *particular* type of harsh climate.

Other Climate Adaptations: Frost tolerance is already being engineered into crops. Tolerance of *more* water (swamp cactus, anyone?) is another possibility. Metabolic modifications could also enable plants to cope with too little or too much sunlight or carbon dioxide. This may be vital if environmental catastrophe looms.

Nutricrops (TL8)

Plants may be genetically altered so that their stored proteins (in cereal seeds or fruits) have more of the essential amino acids that humans and domesticated animals require. This would mean that fewer "nutritional additives" would need to be added to animal feed, or to foods that are packaged for human consumption, reducing agribiz costs.

Exotic Flowers and Lawns (TL8/9)

Flowers, lawn grass, shrubs, house plants or palm trees may be gengineered with exotic aromas (apricot blossoms), colors (electric-blue roses) or even shapes. Some may have bioluminescent genes (from fireflies) spliced into them. The market for exotic flowers may be huge!

Nif Plants (TL8/9)

Cells require nitrogen to build proteins. While animals get nitrogen by eating things, plants extract it from "fixed" nitrogen (ammonia and nitrates) in soil. A major limit on crop yields is infertile soil that lacks nitrogen. Fertilizers work by adding nitrogen to soil, but they are expensive, and many are dependent on (potentially limited) oil supplies.

Some microbes can extract nitrogen gas from the air and create molecules of ammonia, nitrates or other compounds, thus fertilizing the soil. These microbes have evolved to live on the roots of some plants (legumes), but not other species, such as rice or wheat. This is why planting legumes helps restore depleted soil, a technique farmers have known for centuries. TL8 gengineers may be able to develop bacteria that can colonize the roots of non-legume species, or vice versa. A more elegant application (TL9) would be to insert nitrogen-fixing ("nif") genes into crop plants themselves!

Chimera Plants (TL9)

After crop yields are improved, further transgenic gene splicing and a quest for fad food may lead to exotic, cross-species genemod plants, like bananawheat or even beefapples, with unusual flavors or appearances. Another possibility is totally synthetic species, or terrestrial/alien crop genesplices that taste like nothing on Earth.

Manna (TL10)

Very sophisticated gengineering may produce a single food crop that can fulfill *all* human nutritional needs! This would be a boon for any overpopulated planet, since cultivating one crop is easier than many. Of course, even if gengineered to taste good, eating the same thing may get boring after awhile. At TL11+, food crops become less important, as nanotech "protein factories" can synthesize food from basic chemical compounds.

Residential Trees (TL9)

Trees could be gengineered to rapidly grow a huge, thick trunk, with room for hollow spaces inside it and complex, modified roots capable of carrying water for use by the occupants. Gengineered seeds to grow a house-sized tree might cost $5,000, with the tree being ready within two years. Remodeling and decorating the interior (probably installing "cybernetic" plumbing and heating) would an extra $15,000, but even without this, the tree would be useful as a survival shelter. Of course, real estate to grow the tree *on* is extra! In a similar vein, "shelter seeds" which yield giant gourds in mere weeks may be available.

Plants as Bioweapons (TL varies, usually TL9+)

Plants and fungi may be engineered for offensive or defensive purposes, perhaps equipped with poisonous thorns or toxic pollen or spores. One example is given below:

Blood Roses (TL9) are transgenic roses gengineered with poison sacs and more – and tougher – thorns than usual. Someone pushing through a hex of blood roses will take 1d-2 cutting damage. If any damage penetrates DR, a HT roll is required. Failure means taking 3d damage after 10 minutes. The roses retain their poison after being cut (losing one die per day). Someone handling them should make a DX+1 roll to avoid being jabbed (due to the increased number of thorns). A single, cut blood rose costs $50; seeds are $100 each.

Other Biotech Foodstuffs (TL7)

Besides traditional crops, biotech can produce many cheap alternatives:

Algae (TL7) is easily cultured in natural or artificial ponds or lakes, and requires only very simple chemicals, as it gets most of its energy from sunlight. Genemod algae could produce yields several times greater than wheat at very low costs, and be easily harvested and flavored.

Mycoprotein (TL7) is a high-protein, high-fiber "synthetic food" manufactured by the ton from mold cultures. Much cheaper

than meat, but just as nutritious, mycoprotein can be grown using simple starches, or even nutrients derived from the waste products of pulp and paper, cheese-making and other industries. Raw mycoprotein is safe to eat but utterly bland, but it can be modified to look and taste like a variety of foodstuffs, such as meat or fish.

High production start-up costs and consumer resistance in favor of "real food" have limited algae's and mycoprotein's acceptance as human staples, but both are in use as animal feed and food additives. If future overpopulation makes raising cereals, fish or animals too expensive, they may take over, forming a staple diet to feed the hungry masses. Mycoprotein may also be a good choice for spacecraft "food vats."

Fauxflesh Vats (TL9)

NAPANEE (AP) – Acting on an anonymous tip, Ontario Provincial Police raided a factory building on the outskirts of Napanee. They found what one officer called a "disgusting scene, right out of the 20th century": live pigs and chickens being slaughtered and packed by modified agribots for the black-market meat trade. "I thought I'd seen everything in my 10 years on the force," said OPP officer Bill Mackenzie, "But this really turns your stomach, eh?" Police made six arrests.

The carnivore equivalent of hydroponics, fauxflesh may someday make eating meat illegal, or at least unfashionable . . .

Fauxflesh uses the same technology used to grow artificial humans organs and tissues. Gengineered cells made from livestock tissue are cultured in growth tanks, where they are artificially supplied with nutrients. The result is a continuously-growing "biomass" of lean meat tissue that is periodically harvested whenever food is required, or when it gets too big for its vat.

At TL9 and up, spacecraft and colonies that possess full life support can be assumed to have fauxflesh vats, providing meat even if the ship or station is too small to carry actual livestock. A small ship (e.g., one with life support for less than a hundred people) may only have room for a single variety of fauxflesh ("Beef *again?* I'd kill for lamb!") Larger vessels may have different vats growing various kinds of animal cells.

Once fauxflesh becomes available, animal rights groups may be able to convince the general public (and thus governments) to ban animal slaughter as cruel, unusual and *unnecessary* – despite the difference in cost. Of course, the farm lobby may protest – but what if someone gengineers intelligence into a pig or cow, and has it serve as a spokesbeing? If fauxflesh does become the rule, there may even be an illegal trade in manufacturing and smuggling "real meat," just as there is in ivory or whale products today. Shutting down (or running) such an operation could be an interesting cyberpunk adventure.

Gengineered Insects

An insect can be altered and conditioned to transform it into a useful tool, or even a form of organic robot. All references to "insects" below also refer to other small arthropods, like spiders.

Designing Gengineered Insects

These use a simpler version of the system for gengineering humans. See *Designing Plants, Microorganisms and Insects* (p. 97).

Insect Bioweapons

Insect bioweapons are usually stored as vials of eggs and released into still water; in a few hours, days or weeks, they will hatch into tens of thousands of insects.

An area might be seeded with biting insects, such as horseflies or blackflies. Multiple bites cause pain (-1 on DX and IQ until treated) and prevent anyone from getting any sleep (resulting in fatigue).

Other insect bioweapons might be given more subtle targets. While sending genemod moths with a programmed desire to eat the enemy's uniforms is probably more an exercise in whimsy than anything else, a plague of unseasonal pests that eat crops or get into stored grain is no laughing matter, especially if they've been altered to resist the usual pesticides.

For greater lethality, insect pests could be infected to carry specific genemod plagues dangerous to humans or other animals. Often, bloodsucking, winged insects are chosen, such as mosquitos (which can already carry several diseases). In game terms, anyone traveling through an area infested with plague-carrying insects is treated as being in a "plague-ridden" area (p. B133) or area with "special infection" (p. B134) if they lack appropriate repellent, insect-resistant clothing or force fields.

Genetic modification can be used to make an insect bioweapon much more useful. The insects could be designed so that they will not attack if they detect certain chemical cues – which are often odors below the human olfactory threshold. That way, you can protect your own people with a specialized form of repellent.

For even greater precision, insect weapons could be programmed to home in on a specific chemical cue and only attack targets that give it off. This is easy if the enemy are another species, but if (for instance) the enemy uses a particular food, lubricant or laundry detergent and none of the local civilians or your own people do, then you can gengineer your insects to go after them and leave everyone else alone. For the enemy to discover what was happening, they would have to first trace any plague to the insects, dissect the insect to understand what molecules it is reacting to, then correlate this with the odors of all their equipment and supplies. Even with chemsniffers

and computer analysis, this could take weeks. A more trial-and-error approach would be to leave out certain supplies to see if the insects are attracted to them in the absence of humans.

Another modification that could make insect weapons nastier is to redesign them to be resistant to certain common types of insect repellent, or to have pan-specific poison resistance. A pesticide that kills *any* insect can of course be engineered, but this may fatally damage the ecosystem (killing beneficial insects or plants) and have toxic short- or long-term effects on human health as well.

If the technology exists, the best way to deal with genemod insects may be microbot swarms, target-seeking viruses (those that kill insects are "baculoviruses") or nanomachines (see p. RO69 for an example).

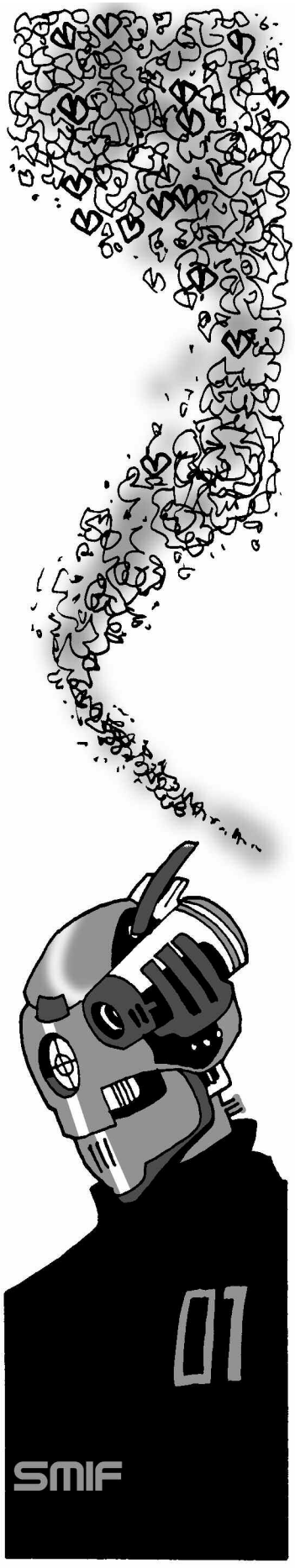
For more insect weapons, see the next section.

Insect Agents (TL9)

An insect agent is an insect or arachnid – such as a mosquito, ant or spider – genetically altered and implanted with biochips to make it an effective covert-operations device. Insect agents are useful for spying, sabotage and assassination.

The insect's genes are tinkered with to make it vastly more intelligent within a limited sphere. While it is IQ 1, it can perform a specific, preprogrammed mission as if it were IQ 6. The engineering also includes a biological clock, which allows the insect to be programmed to perform actions (such as returning to its owner) at specific times. Further modifications permit it to receive and transmit signals, usually via tiny infrared "pits" or modified pheromones. An insect agent does *not* have cybernetic implants – in fact, that is its main advantage: as a totally organic construct, it doesn't show up on sensors that detect power sources or metal.

Insect agents are controlled by *insect directors* (see below), which provide a limited ability to communicate with them. They can be given very simple orders, provided these are unambiguous and within the capabilities of a trained, IQ 6 animal. However, the insect can't be programmed with more than one mission at a time. In general, an insect can be programmed to travel to a landmark or search for a target object it is capable of recognizing. If it finds a target, the insect can then follow it, mark it with pheromones, bite it, deposit a payload upon it or, if the target is tiny enough for the insect to carry, retrieve it.



A major limitation of insect agents is their limited ability to recognize things. In general, an insect will recognize its owner and can be programmed to recognize up to two other things during a mission; for instance, a target building it is to fly to and a person or object it is to find within that building. An insect director can transmit images of specific way stations and targets to the insect along with mission instructions.

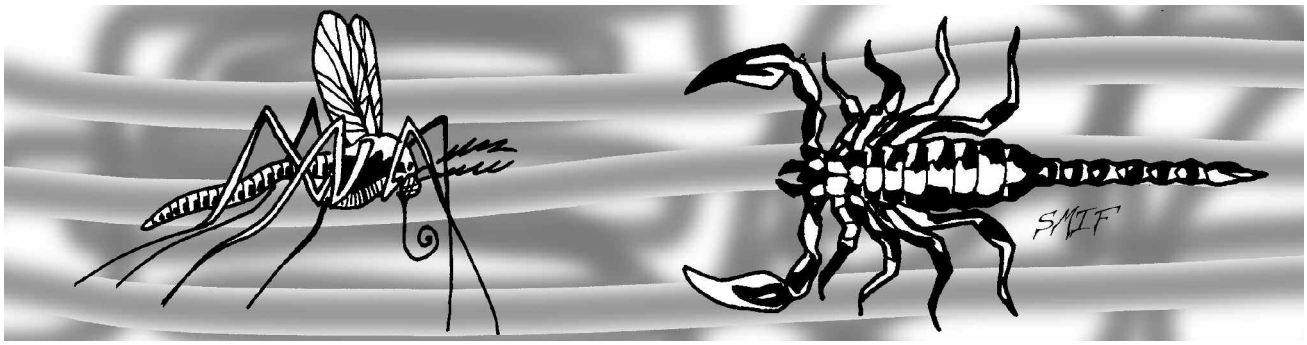
Insect agents have an extremely limited ability to communicate with their owners. They can basically give yes-or-no answers to very simple, mission-related questions such as, "Did you complete your mission?" If in contact with the insect director, they can also upload limited sensory perceptions related to their mission, such as sensory "snapshots" of the seconds before, during and after the objective is reached, along with a general impression of the route taken to the target. These can be experienced directly by anyone accessing the insect director software via neural interface, and will be extremely disorienting – with strange insect-eye views and olfactory cues – but perhaps useful (make an IQ-4 roll to get blurred sensory impressions from it; robots add +4). Alternatively, the computer software can try to overlay it on a map and thus find out where the insect has been.

Insect Director (TL9)

This is a small peripheral, usually attached to a portable computer or built into a robot or suit. Using specialized software (see below), the user can key in or speak simple commands, which are translated into infrared, audio or chemical signals that can be understood by the gene-altered sensory and nervous systems of an insect agent. The director can also receive chemical, audio or infrared reports from the insect agent, which it will translate for the operator. The communicator has a range of only 1 yard, and works best if the insect is actually sitting on it.

Programming an insect agent with a mission normally takes about 5 minutes. The GM can make a secret Computer Programming or Electronics Operation (Security) skill roll to see if this was done properly, with penalties if the instructions seem confusing. Failure means the insect does not do quite what the user intended (GM's option). Critical failure means the program causes the insect to do something totally different from what the user wanted, or causes it to behave in a self-destructive fashion, resulting in its loss or capture.

To work, an insect director must be plugged into a computer running an "insect translation" program (Complexity 4, $4,000). A separate program is required for each brand of insect agent. The director itself is $2,000, 0.25 lbs. (computer not included).



Examples of Insect Agents

Smart Mosquito (TL10)

Amongst the most common insects to be modified are female (bloodsucking) mosquitos. A mosquito's ability to fly, its small size, its excellent sense of smell and, most of all, its ability to be modified to deliver chemicals into the blood make it a highly useful organic platform for covert operations.

A smart mosquito has the usual mental and physical modifications common to insect agents. It also has a pheromone gland that allows it to mark objects with a distinctive scent so that it can find them later. It will always mark its owner.

The insect can fly at about 20 mph. It has an effective Tracking skill of 10, which can be used to find objects or people it has been programmed to recognize. It can be programmed to scent-mark an object it has found. Provided that target is not behind a sealed barrier or more than a mile or so distant, this gives the mosquito +3 on any Tracking rolls to find it later on.

The mosquito can be programmed to perform one of several tasks if it finds its target:

Payload: The mosquito cannot carry anything heavier than a few grains of sand, but sometimes that can be enough! Useful payloads that it can be programmed to pick up or deposit include tiny, pinhead-sized listening devices and messages that are coded as microdots ($1 each). These can also be deposited on someone and scent-marked for later retrieval.

Sampler: The mosquito can draw blood from a subject and retain it without consuming it for up to six hours. This can provide a blood sample for analysis.

Target Marking: Mark the object with a pheromone marker. This can be combined with any other task.

Vector Attack: The insect can carry and transmit a dose of a germ-warfare agent or proteus virus (designed not to affect the mosquito). It may also carry a drug or poison, but as it can only carry a small dose, HT rolls to resist are at +4. Delivery is by biting. This won't penetrate armor, but many people won't even notice a mosquito bite (IQ-2 roll to do so).

If someone is being stalked by a smart mosquito, he should get an IQ-3 roll to notice it (Acute Hearing or Vision helps, as does Alertness). A mosquito-sized insect is -12 to hit due to its small size, but *any* hit will kill it. If the character has a fly swatter or area-effect attack, like bug spray or a flamer, there is only a -2 penalty to hit.

A smart mosquito has a lifespan of only two months. This can be extended by keeping it in suspended animation when not in use. A smart mosquito costs $8,000; it can be carried in a matchbox-sized carrying case. Drugs that are capable of extending the smart mosquito's life span by one month per dose cost $100 per dose. They are effective on a roll of 15 or less; roll each month. Smart mosquitos are LC 3.

Smart Bug (TL10)

A smart ant or small spider uses the same rules as a smart mosquito, except that it is limited to moving on the ground at Move 2, cannot act as a blood sampler, has Tracking-7, and can carry a little more (gives only +2 to resist any drug or poison). While it can't fly, it can walk up walls. Its other advantage is that it's harder to notice, as it's effectively silent; an IQ-4 roll is required to spot an ant or spider sneaking up on you. On the other hand, it's easy to kill – just step on it.

Smart ants or spiders are slightly easier to construct than mosquitos, and cost $5,000. They can also be equipped with two additional biological modifications:

Hardened Mandibles (TL10): This allows the bug to perform sabotage, eventually chewing tiny holes in ducts, slicing wires or biting for 1 point of damage per minute. Add $1,000.

Vacuum Adaptation (TL11): The insect's body has been surgically adapted to survive for a short time (up to an hour) in space, or other high- or low-pressure environments. Add $10,000.

Other Insect Agents

House flies, moths, cockroaches, dragonflies – all might have their own uses. The GM is encouraged to come up with other types of insect agents for specific applications.

Designing Plants, Microorganisms and Insects

New types of plants, microorganisms or insects, for both peaceful purposes and warfare, can be created using either the *New Inventions* rules on p. B186 or the expanded version on pp. CI121-127. Use Genetics (Genetic Engineering)-15. Gengineers should base the design on an existing organism, splicing additional genes into it to produce the desired effect.

Plants, insects and bacteria are usually easier to customize than viruses; apply an extra -2 on all rolls to gengineer viruses. Other suggested modifiers: +1 to +5 for minor variations on an existing organism; +2 to copy a gengineered design if you know it exists and have a description but not a model; -5 if trying something new (up to one TL higher may be possible) or complex. The GM *may* wish to apply an additional modifier of -(TL-6) per extra modification made to the original organism, where "TL" is the minimum TL required for that particular modification.

To make the "conception" roll, the gengineer *requires* a Complexity 3+ computer that is running the appropriate gengineering software.

To make the "working model" roll, a genetics lab (p. 21) and appropriate cultures (or a way of synthesizing them) are needed. Apply modifiers for lab quality; this counts as a "major" task. If creating or modifying a disease, the GM should determine disease statistics using the guidelines given under *Germ Warfare* (p. 87). Add +1 to the working model roll for every assistant with either Genetics (Genetic Engineering) or Biochemistry skill 20+, maximum four assistants.

A critical failure on the *conception* roll generally means that the organism will either do something it wasn't supposed to (for instance, a germ may infect a broader or narrower range of targets than was originally intended) or is totally non-viable. A critical failure on the *working model* roll could mean the accidental release of a dangerous organism; *how* dangerous will depend on what was being designed (but see *Lab Biohazard Precautions,* p. 21). Even if the intended result was non-lethal, there is a slim chance it may mutate to do something it wasn't supposed to – this is up to the GM.

Once a working model has been constructed, it can be cultured in vats and mass produced if a bacteria, or grown from seeds if a plant. Insects may be cloned or hatched normally.

If hiring a scientist to produce work, use the usual rules for hiring and salaries – see the *Job Table,* p. 133.

Engineered Animals

Higher animals – such as fish, dogs or cows – can be bioengineered, often by adding genes from other species. Just like humans, animals can be modified using germline gengineering or through a biomod operation. The former has the potential to create a *race* of modified animals (if a breeding pair is modified). The latter only modifies a single individual, but can usually be performed at an earlier TL.

So why would someone want to gengineer animals? Some possible objectives are described below.

Companions and Working Beasts

Pet owners already enjoy exotic breeds. If laws don't get in the way, we may see dogs with pink fur or strange hybrids like a cat/rabbit. Even if they are illegal, there may still be a black market for radically-altered pets. While society may frown on giving a cat rabbit ears and a semi-intelligent brain for no particular reason, genemods designed to enhance the intelligence of working beasts like sheepdogs, police dogs or horses may be acceptable. At high TLs or in cyberpunk worlds, customized "super pets" could be created by finding a freelance genehacker and having him make a pet to order.

Some societies may even permit the design of "guardbeasts" or "warbeasts" with enhanced combat abilities, derived from deadly animals. These might also be used in ecological warfare. Most such beasts are LC 2-3; those that can breed rapidly might be LC 0-1.

Hardy and Pantropic Animals

Just like plants, animals can be gengineered for improved disease-resistance or to survive changing climates (perhaps brought on by eco-disasters). More exotically, they might be made to smell or taste bad to pests or predators, designed to survive on other planets by splicing in genes so that they can digest alien plants or animals, or modified to survive in unusually harsh climates. For example, "Mars Goats" designed for a partially-terraformed red planet may possess hyper-evolved lungs, internal water storage capacity and thick fur.

High-Yield Farm Animals

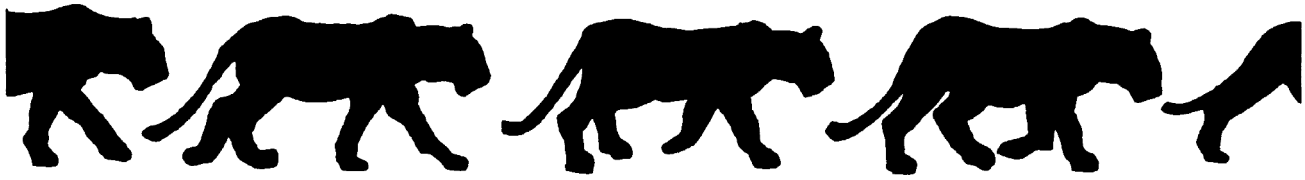
By modifying genes that control growth hormone or fat production, animals can be designed with leaner meat, improved milk, egg or wool production, and other commercially-desirable genemods. Splicing in genes from related species (e.g., putting cow genes in pigs) may also produce larger – or different-tasting! – species. An advantage over post-natal growth hormone treatments is that the animal's descendants will inherit these traits, reducing long-term costs.

One oft-suggested modification would be to give the super-efficient ruminant digestive system found in cows and goats (which uses symbiotic bacteria and a modified intestine to aid digestion) to animals such as pigs. This would allow them to forage, which would reduce the cost of feeding them.

Pharm Animals

Animals can be turned into living pharmaceutical factories by adding genes that code for commercially-useful proteins, or splicing in genes from humans, other animals, bacteria or plants. The advantage of using animals rather than bacteria is twofold. First, more kinds of proteins can be created, since animals have more than one cell to work with. Second, animals do not require the fermentation vats and downstream processing that bacteria need.

Domestic milk animals like goats or cows might be modified so that their milk contains "natural" additives. This process is underway in 1997. For instance, transgenic cows have been grown with genes for lactoferrin, a compound used in human baby formula; this minimizes the need for further processing and reduces production expenses. Pigs have already been grown with human hemoglobin in their blood so they can be bled for human blood substitute. Other animals are being designed to produce germ vaccines.



At TL8+, more exotic "pharm animals" are possible, including ones whose organs can be harvested for use by humans, or whose secretions and bodily fluids (such as milk, blood or urine) or products (such as cheese or meat) contains chemicals or even "wonder drugs" of the sort described in ***GURPS Cyberpunk, Space*** and ***Ultra-Tech.*** A pharm animal could be a highly complex "bio-reactor" if its own genetics were modified *and* its gut also played host to a variety of gengineered bacteria. While the gengineering required is high tech, it would produce drugs and chemicals in a very low-tech fashion, making pharm animals very suitable for developing nations or colony worlds.

Besides their obvious commercial and medical uses, pharm animals could also manufacture illegal chemicals, such as recreational drugs, poisons or even explosives. By modifying a venomous creature into a pharm animal, it might be possible to dispense drugs in combat as well as manufacture them.

Reproductive Modifications

Animals may be gengineered for improved fecundity (giving birth to larger litters, for example), an altered sex ratio (usually, more females to males is desirable), et cetera. Use the TLs given under *Sexual and Reproductive Modifications* (p. 47). Reduce the TL required by 1 when dealing with common lab animals – work on animal reproductive gengineering is well on its way, and will precede similar work on humans.

Near-Sentient and Sentient Animals

Animals can be bioengineered in order to turn non-sentient or pre-sentient animal stock into intelligent species. ***GURPS Uplift*** (pp. U60-77) details slow-and-sure "uplift" procedures aimed at producing stable races; in David Brin's universe, taking two or three hundred years to evolve a species toward sentience is unseemly haste! This book presents a more "cyberpunk" approach to engineered evolution, where species modifications take years, not centuries.

Possible motives for creating a near-sentient or sentient animal include:

Ethical Duty: Some societies or individuals may feel that it is their *duty* to uplift near-sentient animals.

Scientific Curiosity: The project is an experiment. A single evolved critter may be created, or the experiment may proceed to see what kind of society a race of enhanced animals would produce, either in isolation or in partnership with man. If contact with aliens is expected, we might learn a lot by making our own aliens.

Subject Race: The goal may be to produce smarter domestic animals, either for a specific purpose (e.g., as companions or soldiers) or as a general servitor underclass.

Animals with enhanced intelligence can be classed as either *near-sentient* or *sentient.*

A sentient animal is fully intelligent; it doesn't have the Presentient disadvantage (p. CI103) and is at least IQ 8. It may be a full citizen, a slave, or somewhere in between (e.g., a ward of the state or a second-class citizen). It's certainly intelligent enough to resent being treated as anything less than human . . .

A near-sentient animal is either Presentient, has IQ 7 or less, or both. This puts it intellectually halfway between animals and humans. Near-sentients are usually not considered "people." A typical cyberpunk society might not care how near-sentients are treated – corporations could breed near-sentient workers or warbeasts, individuals could go to genehackers to buy upgraded pets, and so on. A more compassionate culture might enforce laws regarding their creation, treatment and ownership, with stringent licensing requirements for individuals permitted to work with them. For example, near-sentient dogs might be used by police, scouts or rangers, but be restricted to specially-trained officers who know to treat them as partners rather than pets.

Creating Biomodified Animals

These rules work best with the *Racial Generation* rules on pp. CI173-180. First, define the racial template as explained under *Unmodified Racial Templates* (below), then modify it according to the guidelines under *Modifying Animals* (p. 100).

Unmodified Racial Templates

Before modifying an animal, determine its *unmodified* racial template in human terms. Guidelines are provided below for translating the animal statistics on pp. B140-145 and in ***GURPS Bestiary*** into racial templates.

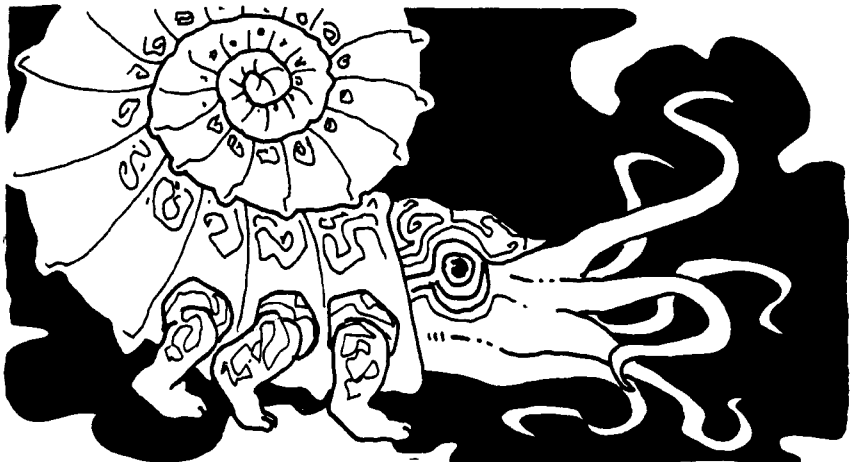
Attribute Modifiers

These can be found by taking the species average and subtracting 10. Thus, a species-average IQ 6 would give a racial IQ modifier of -4. In the case of split HT, calculate HT modifier by subtracting 10 from HT, then find the difference between average HT and hit points to determine how many Extra Hit Points (5 points/level) or Reduced Hit Points (-5 points/level) it has. Thus, HT 12/5 would be HT +2 with Reduced Hit Points -7, while HT 12/15 would be HT +2 with Extra Hit Points +3.

Advantages and Disadvantages

This section lists traits ***by name only.*** *Point costs and detailed rules can be found in* ***GURPS Basic Set*** *and* ***Compendium I;*** *see the included page references.*

Animals with four or more legs have Extra Legs (p. CI55). Those with trunks or tentacles have one or more Extra Limbs (p. CI54) with Extra Flexibility (p. CI55). Birds and bats have Winged Flight (p. CI56). Some animals, like cats



and ferrets, are Double-Jointed (p. B20), while snakes will have Flexibility (p. CI56). Arboreal animals often have Brachiator (p. CI51), Super Climbing (p. CI67) or Super Jump (p. CI68).

Many species can move faster than humans. Find the Move or Speed statistic quoted for the animal in ***GURPS Basic Set*** or ***Bestiary.*** If it is greater than the animal's (DX+HT)/4, add Enhanced Move (p. CI54) in half levels (+50% to Move) or full levels (+100% to Move) to approximately make up the difference. If it's lower, use Reduced Move (p. CI83). For example, a cat (p. B142) has Speed 10 and average DX 14, HT 13. These attributes would only give a human Speed 6.75. Adding half a level of Enhanced Move (5 points) will result in our cat template having just about the correct Move.

Most animals will have some form of body covering, usually either Fur (p. CI56, usually *very light fur, fur* or *thick fur*) or Hide or Scales (p. CI57). Simply select the type that most closely matches the animal's description, PD and DR. Feathers can be treated as very light fur (0 points).

Carnivores normally have *sharp teeth* if they do cutting damage or *fangs* if impaling. Claws are appropriate for some species, such as cats and bears; usually, these are 15- or 25-point claws. Other strikers (e.g., horns) may also be possessed. See pp. CI66-67 for rules covering all of these natural weapons.

Animal senses are normally keener those of humans. In general, animals should have enough Acute Hearing, Acute Taste and Smell or Alertness to give them a roll of 14 or less to sense things. Thus, a cat (IQ 5) would need a +9 bonus. For most species, half this bonus should be Alertness, the rest should be levels of Acute Taste and Smell or Acute Hearing. Animals like canines, with hearing or smell that extends well beyond the human range, should also take Ultrahearing (p. CI69) or Discriminatory Smell (p. CI52). Several species, notably cats, have Night Vision (p. B22). Refer to *Sensory Modifications* (p. 45) for exotic animal senses unique to certain species; e.g., snake Infravision.

Any animal significantly smaller or larger than a human should have Inconvenient Size (p. CI102; -15 points if smaller, -10 if larger). Animals that move on four legs or slither on the ground are Horizontal (p. CI102), with primates being Semi-Upright (p. CI104).

Species with crude hands (like non-human primates) normally have Poor Grip (p. CI101; -5 points), while those with grasping paws, tentacles or a trunk (e.g., raccoons, octopi and elephants) have Bad Grip (-10 points). Species with walking paws or hooves have No Fine Manipulators (p. CI103), while those with no limbs (e.g., snakes, most sea creatures) have No Manipulators (p. CI103). Animals restricted to water (like fish, dolphins and whales) are also Aquatic (p. CI101).

Many animals have lifespans and sleeping habits that differ drastically from those of humans. In general, most (but not all!) non-human species have one or more levels of Short Lifespan (p. CI104). Many have either Sleepy (p. CI104) or Less Sleep (p. CI27). Big herbivores don't sleep much (2-4 hours/day for cows, deer, horses and so on), while mid-size carnivores and small omnivores often sleep 50-75% of the time.

Even if they were intelligent enough to talk, most animals (with the exception of some birds like parrots) lack the vocal equipment to produce human speech. This is Mute (p. B29).

Most animals lack imagination and curiosity when compared to humans. "Presentient" species include animals with high intelligence and complex behavior, such as monkeys, some cats and canines, raccoons, dolphins and possibly other IQ 5-7 species. They typically have the Presentient disadvantage (p. CI103) and one or more of Dull (p. CI89), Innumerate (p. CI91) or Staid (p. CI94). A Dull and Staid animal is not *stupid!* It just prefers to follow instinctive behavior patterns rather than innovating, and lives day-to-day, ignoring matters that don't immediately affect it.

"Non-sentient" species – most species with IQ 4 or less, and possibly some with higher IQs – also have the Presentient and Innumerate disadvantages, but replace Dull and Staid with the more severe disadvantages Hidebound (p. CI91) and either Incurious (p. CI91) or Obdurate (p. CI92).

Predator species usually have Combat Reflexes (p. B20), and those that track prey may be Attentive (p. CI86) or even Single-Minded (p. CI30). Grazing herbivores often have Slow Eater (p. CI104). Many wild animals, including a lot of supposedly "fierce" predators, are Edgy (p. CI90). Pack or herd animals are typically Chummy (p. CI87) or Gregarious (p. CI90).

Other advantages may be unique to certain species; e.g., Amphibious, Catfall, Metabolism Control (Hibernation), Perfect Balance, Venom and so on.

Modifying Animals

Once the racial template has been determined, use the rules for human gengineering (Chapter 2) and biomods (Chapter 3) to make any modifications. The key difference is that animals may already have certain attribute modifiers, advantages or disadvantages without the need for gengineering.

Gengineers may also want to remove some disadvantages native to animals. Some suggested modifications are described below. These may also have *side effects* (unintended disadvantages). As side effects aren't deliberate modifications, they don't affect the difficulty or dollar cost of the modification process, but they *do* reduce the race's point cost.

Some special considerations that apply to gengineering animals:

Animal Intelligence

Modifications to the brain's size or structure can improve racial IQ. These include enlargement of the frontal lobes, modifying the language and creative centers, and other changes intended to improve reasoning ability and abstract thought. Use the rules for enhancing human intelligence (p. 30); that is, germline gengineering can add up to +2 IQ at TL10 and +4 at TL11+. For biomods, see *Brain Tissue Graft* (p. 71) and *Neurovirus* (p. 79).

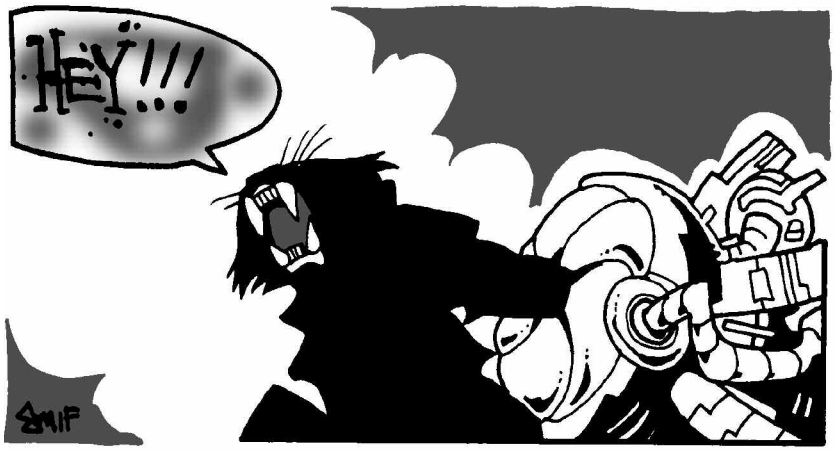
The Presentient disadvantage can be bought off at TL9 if the average racial IQ is 6 or higher. At TL10, further modifications can be performed to remove or buy down racial mental disadvantages such as Dull, Edgy, Hidebound, Incurious, Obdurate or Staid.

A side effect of increasing IQ is to reduce an animal's sensory bonuses, as more of the brain is devoted to reasoning and language processing. For every +1 increase in IQ, reduce Alertness or *all* Acute Senses by one level. Altering IQ or buying off Presentient or other racial mental disadvantages often produces Stress Atavism – see p. CI105 for details.

Enhanced Manipulatory Ability

The extent of the modifications possible at a given TL depends on how promising the species is!

Modified Hooves, Flippers or Walking Paws: Species like horses, dolphins or dogs that completely lack hands require fairly extensive modification to remedy this. At TL9, they can be given grasping paws, replacing No Fine Manipulators (p. CI103) with Bad Grip (p. CI101). At TL10, they can be given crude hands, giving Poor Grip (p. CI101). At TL11, No Fine Manipulators can be bought off entirely.



A side effect of modifying paws or hooves on a four-legged animal is to remove its Extra Legs (p. CI55) advantage (since they are now feet manipulators or arms) along with any Enhanced Move (p. CI54) the animal has. This reduces its racial cost. If it had no Enhanced Move, give it one level of Reduced Move (p. CI83). If not using a racial template, just reduce Move to (DX+HT)/4.

Modified Grasping Paws: At TL9, species like raccoons can be given crude hands, replacing Bad Grip with Poor Grip (see p. CI101). At TL10, Bad Grip can be completely bought off by creating real hands. Movement effects are the same as described above.

Modified Crude Hands: At TL9, species with crude hands, such as chimpanzees, can be modified to have human-like hands. This buys off Poor Grip.

Modified Tentacles or Trunk: Species like octopi and elephants can have their tentacles or trunk modified with manipulatory ridges, buds or tendrils. At TL9, this improves Bad Grip to Poor Grip (see p. CI101). At TL10, it can buy off any manipulatory disadvantages.

These modifications can also be created with transplant surgery. Cost is $20,000 × (TL-8) where "TL" is not the current TL but rather the minimum TL required. The procedure takes 6 weeks and is LC 5. Metamorphosis nanovirus (p. 79) can also improve manipulatory ability.

Enhanced Voice Box

It's possible to modify the animal's voice box to make it capable of human speech. This can be added to any mouse-sized or larger animal. At TL9, gengineering can upgrade the Mute disadvantage to Stuttering (see p. B29). This represents an animal that can speak, but has trouble doing so. At TL10, Mute can be completely removed.

A Presentient animal which has an enhanced voice box can learn a language at up to skill 8. This is an exception to the usual prohibition against Presentient races learning spoken languages; the rule in ***Compendium I*** was written under the assumption that animals were not gengineered with voice boxes!

An enhanced voice box can also be created using surgery. The cost is $10,000 × (TL-8) where "TL" is not the current TL but rather the minimum TL required. Time is 2 weeks to change Mute to Stuttering, or 6 weeks to for human-level speech. Metamorphosis nanovirus (p. 79) can also enhance a voice box.

Modified Posture

A species with legs can be modified from a Horizontal posture like a horse or dog (p. CI102) to Semi-Upright (p. CI104) like an ape, or from Semi-Upright to an upright bipedal posture like a human (0 points). This requires spinal modifications as well as replacing front paws/hooves with grasping paws, crude hands or hands (see above). A change of Horizontal to Semi-Upright or of Semi-Upright to upright is TL9. One of Horizontal to upright is TL10.

An alternative (and somewhat cinematic) "uplift" for horizontal posture is to radically alter their body to create a Centauroid (p. CI101) form. This requires the deliberate addition of two extra arms (as described for humans, p. 40), and requires TL11.

For species two hexes or more in size, the usual side effect of becoming bipedal is a loss of size, represented by lowered ST and hit point bonuses. It's suggested that both be reduced by at least one-third, with much greater reductions being quite possible.

These modifications can also be created using surgery. The cost is $50,000 × (TL-8) where "TL" is not the current TL but rather the minimum TL required. This takes 8 weeks. Metamorphosis nanovirus (p. 79) can also improve manipulatory ability.

Pharm Animal Modifications

In game terms, pharm animals (p. 98) are created by taking the Drug Factory advantage (p. CI53). The TL required should be based on the TL of the drug (see pp. UT97-100 and CY57-59 for various drugs):

At TL8 or the drug's TL, whichever is *higher,* a drug factory can produce blood products, or exotic proteins that can be synthesized into drugs – or perhaps other products – given further processing (but for only 10-20% of the cost of producing the drug in the normal laboratory fashion).

At TL9 or the drug's TL+2, whichever is *higher,* a drug factory can be designed to produce "ready-to-use" drugs.

If the animal can produce multiple different compounds, add +1 to the highest TL for two drugs or +2 for three or more.

At the GM's option, it may be impossible to produce some drugs using pharm animals, regardless of the TL. Alternatively,

perhaps their production has severe side effects on an animal's metabolism, giving it various disadvantages (or even exotic advantages).

If a drug is "ready to use" and the animal has sharp teeth or claws, the drug can be delivered with a normal attack. If the drug cannot be delivered actively, or is not ready to use (the animal must be bled, milked or whatever, taking several minutes or longer), this is a -70% limitation – or -75% if the drug must be processed as well. On the other hand, some animals might be able to spray drugs as ink, musk or urine, or even secrete drugs through their skin; if so, use the special enhancements for Venom (p. CI71) as guidelines.

The usual production rate is one dose every 4 hours, to a maximum of HT/2 doses, as described in the Drug Factory advantage. For animals smaller than humans, GMs should base it on the *lower* of HT or hit points; for creatures larger than humans, use the *higher* of the two.

Munition Mares, Guerrilla Goats and Bomb Bovines (TL9): A milk-producing animal (typically a cow, nanny goat or mare) could be gengineered so that curd formed from its milk can, with minimal preparation, be formed into a stable and potent biochemical explosive. This is a Drug Factory, as above, with each "dose" of drug equivalent to 0.1 lb. of explosive. Assume biological explosives that do about 6d damage per pound are TL8 chemicals, or TL10 if they are "ready to use."

Bio-Bombs (TL10): A creature may be gengineered into a "living bomb" that can actually blow itself up! This costs 2.4 points per 1d of explosive concussion damage (6 points/1d; Explosive Effect, +40%; blows self up, -100%). The maximum number of levels is (creature's weight/100 lbs.) at TL10-12. At TL13+, the creature can actually have a solid-fuel skeleton and structural tissues, allowing a maximum explosive damage of (weight/20 lbs.).The creature takes five times damage from its own explosion, with no DR protecting it. The explosion is usually designed to take place if the creature dies violently; bio-bombs can also be fitted with chemical triggers (p. 139) or biochips (p. 138) that will activate hormones that set them off after receiving a coded transmission, coming into contact with a particular target, et cetera.

Sample Gengineered Animals

These Earth animals have been biomodified in ways that make them more useful to people. Animals may be purchased from a biotech company as embryos, as young or as adults. If a breeding pair (or herd) is acquired, they can be bred normally, provided they aren't sterile. Sterile versions of otherwise-fertile biomodified animals can usually be purchased at half cost or less.

A list of the changes (in game terms) that each animal has undergone has been appended to the description, so that GMs can alter the templates to create other versions of the same species.

Lab Mice (TL7)

These are mice that have been adapted to be genetically closer to humans, for use in lab experiments. Their statistics are identical to normal mice – i.e., inconsequential – but they can catch (and carry) the same diseases that humans can.

Pharm Goat (TL8)

ST: 10 **Speed/Dodge:** 9/6 **Size:** 1
DX: 13 **PD/DR:** 1/0 **Weight:** 50-300 lbs.
IQ: 4 **Damage:** – **Habitat:** M, P
HT: 13/8 **Reach:** –

A nanny goat, modified to produce components that can be used to make a single TL8 compound, such as infant formula, a cancer vaccine, super steroids, an enzyme blocker or maybe a wonder drug (like the super clotting agent Hypercoagulin, p. UT97). Modifications were Drug Factory (requires processing: must be milked, -75%, 5 points). Unintended side effects were -2 HT (not hit points) and Unusual Biochemistry (compared to an average goat).

Neo-Vampire Bat (TL9)

ST: 2 **Speed/Dodge:** 12/6 **Size:** <1
DX: 13 **PD/DR:** 0/0 **Weight:** Neg.
IQ: 4 **Damage:** 1 hit **Habitat:** J
HT: 13/2 **Reach:** C

An example of an exotic bioweapon that might come out of an underground cyberpunk biolab, this transgenic vampire bat has been gengineered with poison sacs (Venom; p. CI71) and a bloodhound's sense of smell (Discriminatory Smell; p. CI52). Capable of identifying and tracking down a specific target by scent and sonar, it is an exotic "black ops" weapon.

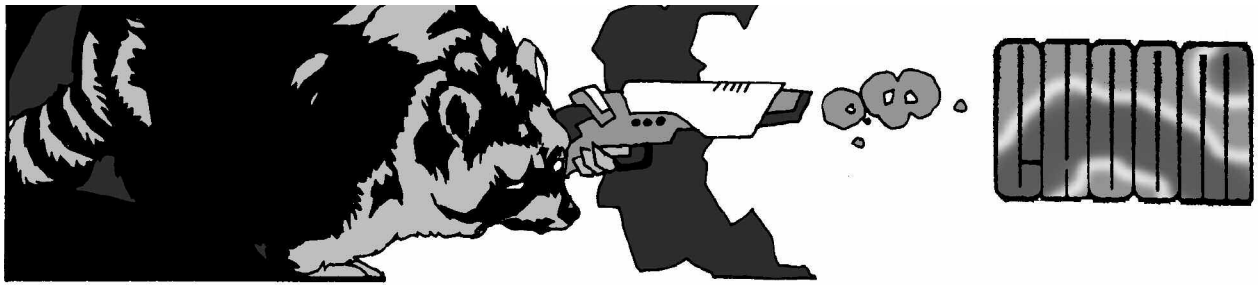
Jagrilla Hound (TL10) 37 points

I'd heard the government was using cloned warbeasts against the insurgents, but I'd never seen one until the general brought his bodyguard to the cease-fire talks. It was like a 7-foot-tall gorilla, but with a jaguar's pelt, a canine muzzle and long, pointed ears. The eyes were the worst: glittering with intelligence not quite human. It wore combat webbing and cradled an M-22 assault cannon in its clawed hands. As I approached them, the warbeast sniffed the air and growled something to its master. I was afraid it could smell my fear.

– "War in the Andes," by Captain Dana Martello, *Stars and Stripes,* Oct. '53

ST +4 (45 points), DX +2 (20 points), IQ -2 (-15 points), HT +2 (20 points).

Racial Advantages: Acute Hearing +2 (4 points), Combat Reflexes (15 points), Discriminatory Smell (works as Empathy



within 2 hexes, +50%, 23 points), Extra Hit Points +2 (10 points), Fearlessness +3 (6 points), Fur (4 points), High Pain Threshold (10 points), Night Vision (10 points), Sharp Claws (25 points), Sharp Teeth (5 points), Single-Minded (5 points), Super Jump 1 (10 points).

Racial Disadvantages: Appearance: Monstrous (-25 points), Bloodlust (-10 points),Hidebound (-5 points), Innumerate (-5 points), Poor Grip (-5 points), Semi-Literacy (-5 points), Semi-Upright (-5 points), Sense of Duty (master, -5 points), Short Lifespan 3 (-30 points), Sleepy (50% of time, -10 points), Sterile (-3 points), Stress Atavism (mild, common, linked to Bad Temper, -17 points), Stuttering (-10 points), Subjugation (-20 points), Unusual Biochemistry (-5 points).

This is a cross-species fusion (p. 26) of gorilla and jaguar, modified for +2 IQ (to IQ 8), a near-human voice box that reduces Mute to Stuttering, and canine genes that give it a dog's Discriminatory Smell. Unintended defects are Monstrous, Sterile, Stress Atavism and Unusual Biochemistry.

K-10 (TL10) -1 point

These are semi-sentient, domesticated canines. They resemble large dogs or wolves, but their skulls are somewhat larger, with a higher cranium. Their voice boxes are modified to allow them to speak, although words have a strong, growling "canine accent."

Likely owners include rich people, police, customs agents, hunters, security agencies, farmers and exploration teams. A K-10 would also make a good seeing-eye dog, but the technology base needed to create them can probably cure most forms of blindness. The armed forces might find neo-dogs useful for military police or rangers, often with added cybernetic or biomod enhancements.

DX +3 (30 points), IQ -3 (-20 points), HT +2 (20 points).

Racial Advantages: Alertness +7 (35 points), Discriminatory Smell (works as Empathy within 2 hexes, +50%, 23 points), Enhanced Move (Running) 1 (10 points), Extra Legs (four legs, 5 points), Fur (4 points), Sharp Teeth (5 points), Ultrahearing (5 points).

Racial Disadvantages: Chummy (-5 points), Color Blindness (-10 points), Horizontal (-10 points), Innumerate (-5 points), No Fine Manipulators (-30 points), Proud (-1 point), Responsive (-1 point), Semi-Literacy (-5 points), Sense of Duty (master, -5 points), Short Lifespan 2 (-20 points), Sleepy (50% of time, -10 points), Stress Atavism (mild, uncommon, -6 points), Stuttering (-10 points).

The K-10 is produced by TL10 germline gengineering of canine stock. Modifications are increased IQ +2 (to IQ 7), the removal of Dull and Staid, and an enhanced voice box that reduces Mute to Stuttering (37 points of changes). The only unintended defect was Stress Atavism. All the other advantages and disadvantages are native to canines

Larger or smaller K-10 breeds are also possible, although further gengineering may lead to more disadvantages as well. A trained "attack dog" might have Bad Temper or even Bloodlust.

Neo-Coon (TL10) -56 points

Missing: Two raccoons, aged 3 and 4 E-years. Gray fur, distinctive black mask marking over eyes, rings on tail. $10,000 reward for information leading to recapture. Please contact Macrotech@Fed.Net.Com

"Let's see if I understand this. Two of our Doolittle Virus-enhanced Neo-Coons faked a stomach ache, lured you into the cage, took your tangler and glommed you to the wall. Now they're loose. Where would they go?"

"I don't know, sir. These ones were being trained by the Bureau for covert ops, but we hadn't completed indoctrination – there were some problems in training. Anyway, after they jumped me, they used the computer to send out e-mail, then wiped the system."

"Used the computer? How? We didn't modify their hands! They're supposed to look like ordinary raccoons!"

"Even normal 'coons have good grasping paws, sir. That was the whole point of using them. Our Neo-Coons can't talk, but they can type and use tools if they're sitting on their haunches. I just wish I knew who they were trying to get in touch with . . ."

ST -6 (-50 points), DX +4 (45 points), IQ -2 (-15 points), HT +2 (20 points).

Racial Advantages: Alertness +6 (30 points), Sharp Teeth (5 points), Thick Fur (29 points).

Racial Disadvantages: Horizontal (-10 points), Mute (-25 points), Poor Grip (-5 points), Reduced Hit Points -6 (-30 points), Short Lifespan 2 (-20 points), Sleepy (50% of time, -10 points), Subjugation (-20 points).

These were modified for increased IQ +2 (to IQ 8). All other advantages and disadvantages are native to raccoons.

Neo-Horse (TL10) 68 points

This is an uplifted riding horse. It isn't sentient by any means, and can't talk, but it's as bright as a chimp and can do anything a "movie" horse can do, and then some. This particular model has been further redesigned so that its spleen produces enhanced, disease-fighting leukocytes.

ST +30 (No Fine Manipulators, -40%, 108 points), IQ -4 (-30 points), HT +3 (30 points).

Racial Advantages: Alertness +8 (40 points), Disease-Resistant (5 points), Enhanced Move (Running) 1.5 (15 points), Extra Legs (four legs, 5 points), Less Sleep 5 (15 points), Peripheral Vision (15 points).

Racial Disadvantages: Hidebound (-5 points), Horizontal (-10 points), Inconvenient Size (-10 points), Innumerate (-5 points), Mute (-25 points), No Fine Manipulators (-30 points), Presentient (-20 points), Short Lifespan 1 (-10 points), Subjugation (-20 points).

These were modified for +2 IQ (to IQ 6) and +1 DX (to DX 10), with an augmented spleen that provides Disease-Resistant. All other advantages and disadvantages are native to horses.

Octosap (TL10) -53 points

Guys, you won't believe this! You know we tried to scope GenPacifica's Deepstralia III, got chased off by the security? Well, second time's the charm: We got Tegan's sonofish to distract their war-dops, then went to max on the aquasleds. The Pacifica vent mine's as big as rumored, but get ready: Their construction workers ain't seal bioroids – they're genemod octopi! I'm not raptured, gridfriends; these are definitely gengineered bioroids, they were working with their tentacles. And their heads – brrr. Like, an octo with a face, you know? Check out my site for the movie! Better hurry, though. My sysop says she's getting some threatening email from GenPacifica.

– Aquagrrl, alt.ocean.development.korporate.otaku

Octopi are among the most intelligent non-mammalian aquatic creatures. I'm surprised that no one has attempted uplift before. I suspect these were surgically augmented, rather than truly gengineered, and I doubt they're much more intelligent than a dog. Still, a dog with tentacles? Interesting thought.

– DocIqbal, alt.ocean.development.korporate.otaku

ST -4 (-30 points), DX +4 (45 points), IQ -5 (-40 points), HT +2 (20 points).

Racial Advantages: Alertness +7 (35 points), Chameleon 2 (14 points), Constriction Attack (15 points), DR 1 (3 points), Enhanced Move (Swimming) 1/2 (5 points), Extra Arms (six, 60 points), Extra Flexibility (10 points), Gills (0 points), Sharp Teeth (5 points), Smoke (ink: only in water, -30%, 11 points).

Racial Disadvantages: Aquatic (-40 points), Bad Grip (-10 points), Bad Sight (-10 points), Cold-Blooded (-5 points), Edgy (-5 points), Hidebound (-5 points), Incurious (-5 points), Innumerate (-5 points), Invertebrate (-20 points), Mute (-25 points), Presentient (-20 points), Reduced Hit Points -6 (-30 points), Short Lifespan 2 (-20 points), Stress Atavism (mild, uncommon, -6 points).

The only change made to an ordinary octopus was to raise IQ by two (to IQ 5). The only unintended disadvantage was Stress Atavism. All other advantages and disadvantages are native to octopi.

Space Cat (TL10) -46 points

Order: One Felis domesticus, female siamese, with following genemods: augmented intestinal fauna, boosted brain, internal gravity web, jacked-up immune system.

"I had them grow Tarot for me after those parasite bunnies got into the fiber optics on our last run. With Tarot on the prowl, no xeno-rodent's going to run wild on my ship."

– Captain Zeke Morrigan, free trader *Antares*

ST -7 (-60 points), DX +4 (45 points), IQ -3 (-20 points), HT +3 (30 points).

Racial Advantages: Acute Hearing +3 (6 points), Acute Taste and Smell +3 (6 points), Alertness +4 (20 points), Cast Iron Stomach (15 points), Catfall (10 points), Claws (15 points), Combat Reflexes (15 points), Discriminatory Smell (15 points), Enhanced Move (Running) 1/2 (5 points), Extra Legs (four legs, 5 points), Faz Sense (Eye Contact Only, -20%, 8 points), Fur (4 points), Immunity to Disease (10 points), Improved G-Tolerance (1 G increment, 15 points), Night Vision (10 points), Perfect Balance (15 points), Sharp Teeth (5 points), Ultrahearing (5 points).

Racial Disadvantages: Dull (-1 point), Horizontal (-10 points), Impulsiveness (-10 points), Inconvenient Size (-15 points), Innumerate (-5 points), Mute (-25 points), No Fine Manipulators (-30 points), Presentient (-20 points), Proud (-1 point), Reduced Hit Points -10 (-50 points), Responsive (-1 point), Short Lifespan 3 (-30 points), Sleepy (66% of the time, -20 points), Staid (-1 point), Stress Atavism (mild, uncommon, -6 points).

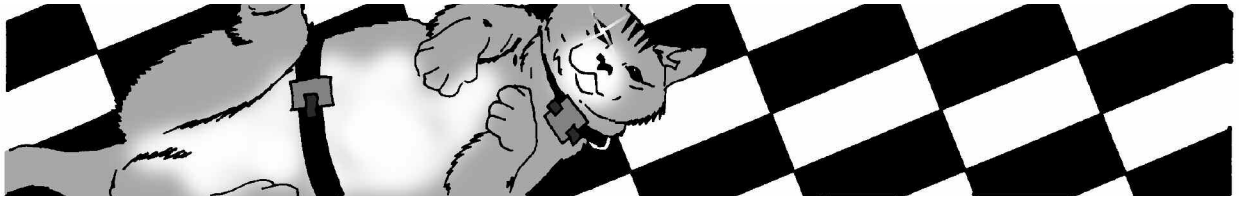
The changes made to an ordinary cat were to raise its IQ by two (to IQ 7) and add Cast-Iron Stomach, Immunity to Disease and Improved G-Tolerance. The only unintended disadvantage was Stress Atavism. All other advantages and disadvantages are native to cats.

War-Dop (TL10) 32 points

"Navy's been using conditioned dolphins since the 20th century – and the program's been continuing, though under pretty deep cover, mostly out of PR concerns. Some corporate security outfits are also using them. Recon, mine detection, counter-diver missions and counter-terrorist security at oil rigs and such. War-Dop E's the new generation. The D-model was packed full of cyberwear implants, but they were too easy to detect. Aside from some minor brainwork, this model's blowhole's been modified for human language, and it has a bioelectric musculature based on an electric eel with built-in EM field-sensing capabilities."

– Captain (ret.) Dana Martello, Marine Force Recon

"Last year, Blue Shadow ecowarriors, with some inside help, raided the dolphin training farm at Pearl and liberated a couple of E-model War-Dops before the conditioning process could be completed. Friend of mine in the Movement says one of



the dops has joined up with the Shadow boys, but he isn't too stable."

– Aquagrrl, alt.ocean.development.korporate.otaku

ST +3 (No Manipulators, -40%, 18 points), DX +3 (30 points), IQ -2 (-15 points), HT +1 (10 points).

Racial Advantages: Absolute Direction (5 points), Acute Hearing +4 (8 points), Bioelectric Shock (10 points), Enhanced Move (Swimming) 2 (20 points), Extra Hit Points +5 (25 points), Field Sense (10 points), Sonar Vision (25 points), Ultrasonic Speech (25 points).

Racial Disadvantages: Aquatic (-40 points), Bad Sight (-10 points), Chummy (-5 point), Distractible (-1 point), Dull (-1 point), No Manipulators (-50 points), Stress Atavism (mild, common, -12 points), Subjugation (-20 points).

The changes made to ordinary dolphins were to add Bioelectric Shock and Field Sense, and to buy off Mute. The only unintended result was Stress Atavism.

Neo-Gorilla (TL11) 142 points

"Discrimination at the construction site? Well – there were a few banana and Tarzan jokes when I started. Yes, ma'am, but we're used to them. Nothing nasty. No one wants to get their arms ripped off, see. Uh, that was a joke, ma'am. Of course I wouldn't do anything like that. I got along with the napes – I mean you humans – just fine. Uh, naked apes, ma'am. You humans. Bad habit I picked up, I admit. Yes, I won't use it again, ma'am."

ST +8 (90 points), DX +1 (10 points), IQ -1 (-10 points), HT +4 (45 points).

Racial Advantages: Alertness +2 (10 points), Extra Hit Points +4 (20 points), Fur (4 points).

Racial Disadvantages: Proud (-1 point), Short Lifespan 1 (-10 points), Sleepy (50% of time, -10 points), Stress Atavism (mild, uncommon, -6 points).

Modifications make the gorilla's crude hands into human-equivalent ones (buying off Poor Grip), improve the voice box to human levels (buying off Mute) and alter the spine (removing Semi-Upright). Adjustments to the brain eliminate Edgy and Presentient, and add +3 to IQ (to IQ 9), for a total of 90 points of changes. Side effects were mild Stress Atavism, a loss of one level of Alertness and, due to the change in posture, a loss of one-third the gorilla's natural ST bonus (from ST 22 to ST 18).

Ursamorph (TL11) 179 points

"Bob, what did you do with my Ursamorphs?"

"Research program's finished, Judy. You did your part. Your bears can talk, manipulate things and they're mentally stable. Now we're in the next stage. They're at Fort Drum, with Henderson."

"Fort Drum? That's–"

"Combat training, Judy."

"You're teaching Uther and Terri to shoot ***guns?*** *Bob, it's wrong! I designed the Ursamorphs to hibernate during the long voyage, then help build the Mars Base. They're space construction workers – astro-engineers!"*

*"****Combat*** *engineers, Judy. Get used to it. Mars Base is being trimmed. The program funding might be cut at any time. But you should see the film from Fort Drum – an Ursa can hip-fire an assault cannon or a Snapdragon missile! Their fur even gives them good thermal camo. The* ***Pentagon*** *liked the Ursas. It's a big defense contract, Judy. Bigger than this Mars stuff."*

ST +9 (100 points), DX +2 (20 points), IQ -2 (-15 points), HT +4 (45 points).

Advantages: Alertness +6 (30 points), Claws (15 points), DR 1 (3 points), Extra Hit Points +5 (25 points), Metabolism Control 4 (Hibernation, -50%, 10 points), Sharp Teeth (5 points), Thick Fur (29 points).

Disadvantages: Bad Temper (-10 points), Dull (-1 point), Inconvenient Size (-10 points), Innumerate (-5 points), Poor Grip (-5 points), Short Lifespan 1 (-10 points), Sleepy (50% of time, -10 points), Staid (-1 point), Stress Atavism (mild, uncommon, -6 points), Stuttering (-10 points), Subjugation (-20 points).

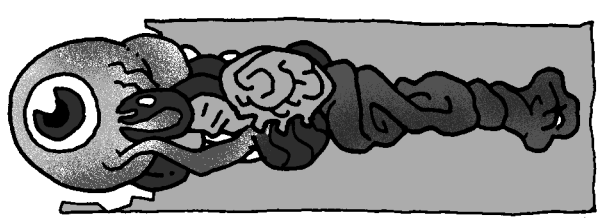
The changes made to your ordinary bear were to raise IQ by three (to IQ 8), change No Fine Manipulators to Poor Grip, reduce Mute to Stuttering and remove Presentient and Semi-Upright. The only unintended defect was Stress Atavism. All other advantages and disadvantages are native to bears.

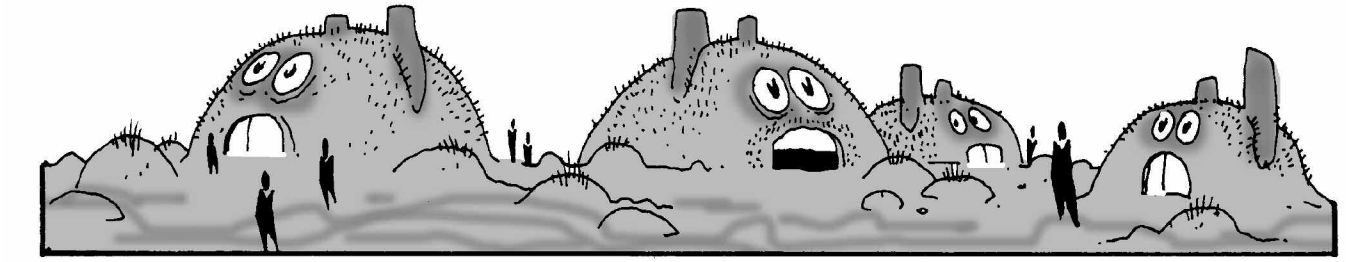
Biogadgets

A biogadget is a living plant or animal that has been gengineered into functioning as a device or tool. This type of technology is most common in cultures that possess advanced biotech, but lack equally-advanced metallurgical and high-energy technologies (or the opportunity to develop them; e.g., a culture living underwater, inside a gas giant atmosphere or on a metal-poor planet). Biotechnology may also represent a deliberate choice (perhaps for environmental or even aesthetic reasons). To foreign cultures, biogadgets may seem very alien, but they could perhaps be profitably traded. The creation of biogadgets generally requires TL11+ biotechnology.

The primary advantages of most biogadgets are self-maintenance and self-repair. They heal at the same rate as living organisms if damaged but not destroyed. They also require minimal maintenance if healthy. However, the GM could always rule that they can get sick or contract diseases.

Many of the devices described in ***GURPS Cyberpunk, Space*** and ***Ultra-Tech*** could potentially be biogadgets (the bio-suits on p. UT26 already are). Mostly, it's just a matter of changing their description – an exoskeleton could be formed of living bones and muscle, a respirator might be a living creature that you breathe through, and a bug detector could resemble a snail with big antennae that hisses when it senses electromagnetic emissions. Biogadgets may communicate with each other not via cables or communicators, but by pheromonal signals.





Of course, biogadgets need not all have adventuring utility. People could sleep on *fleshbeds* – masses of living flesh which function just like waterbeds. Most grow their own hair or fur, available in a wide range of styles from "traditional" motifs, like a big cat pelt, to hair cloned from famous media stars – although some people prefer the feel of naked skin. Some "deluxe" models are additionally gengineered to produce sex pheromones (HT roll to avoid temporary Lecherousness)! A fleshbed might cost $1,000, or $5,000 for the deluxe model.

A biogadget probably should not have more than PD 3 or DR 15 (most will be PD 0, DR 0, just like human skin). It also shouldn't be something that involves especially energetic radiation emissions (like a beam weapon, force sword, ultrascanner or laser communicator) or whose design requires the structural strength of metals or ceramics (like a chemical-propellant firearm or combustion engine).

A biogadget doesn't use power cells for energy; instead, pick one of the options below. Apply any cost multipliers to the cost of the regular, unliving version of that gadget. Options include:

Bioconvertor Power Plant: Gadgets (especially big ones) could be connected to a specialized organism designed to consume food and produce power – a "bioconvertor." See p. RO35 and p. VE86 for details of bioconvertor engines.

Body-Powered: This is available for gadgets that are worn next to the skin (or implanted), such as suits or goggles. The gadget is powered by the user's body heat, lives off his bodily secretions, et cetera. Double cost; the gadget will cease working when not in contact with the user's flesh.

Fixed: As *Nutrient Bath* or *Rooting* (below), but the device won't work unless it's within the nutrient bath or fertile soil, and it can't be removed from its bath or soil without dying. This is typical of large, fixed gadgets. Halve cost if it can use normal soil; divide cost by 4 if it requires nutrients. This is cumulative with the cost modifier for Nutrient Bath or Rooting.

Nutrient Bath: The gadget absorbs nutrients through its skin. It will operate for half as long as a power cell–operated gadget would, but then needs to be placed in a nutrient solution to recharge (takes at least 8 hours). A nutrient solution pack can be emptied into any suitable container big enough for the gadget. A device requires 0.1 oz. of nutrient solution if the unliving version requires an AA cell, 1 oz. if an A cell, 4 oz. if a B cell, 2 lbs. if a C cell, 10 lbs. if a D cell or 40 lbs. if an E cell. A single package of nutrient solution costs $10 per pound and stays fresh for a month. Double cost.

Rooting: The device will operate for just as long as a power cell–operated gadget would, but then needs to be placed in moist, fertile soil for at least eight hours. It will uncoil roots and suck necessary nutrients into its body in order to recharge. Triple cost.

Solar-Powered: The gadget's skin can convert light to electricity. It works constantly in sunlight or strong artificial light. In darkness, it can work for 1% of the duration listed for a normal gadget of the same type before running out of power. Double cost.

Bio-Buildings: Buildings can be *grown* using bio-nanotech. At TL10, the result is an empty, unfurnished building with an exotic organic shape and texture, perhaps suggestive of coral, chitin, a sea shell or a bee hive. At TL11+, the building can be *alive,* with self-healing (perhaps even edible!) walls, mutable rooms that can change color, scent or texture on demand, and floors that extrude living furniture. It could even be chemically persuaded to resume its growth when more stories are needed. (This cuts both ways, though: a growing or live building might be vulnerable to biochemical attack.) A bio-nanotech "seed" costs about one-tenth what the resulting building would cost to build conventionally. Growth takes (seed cost/1,000) hours.

Sentient bio-buildings are also possible – see p. 111.

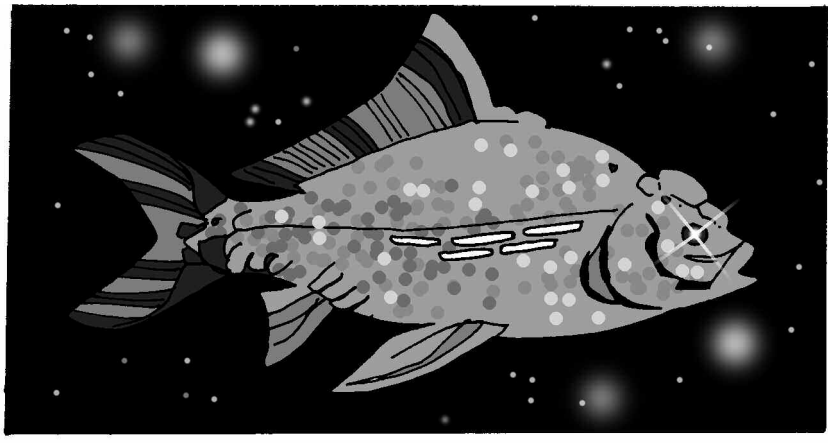
Bioships

"Bridge, this is Falcon Two. I have a visual on the alien ship, and – you're not going to believe this, captain, but it's shaped like a giant eel, only covered in spines! Sort of an organic-looking hull, but with metallic blisters that look like turrets embedded in it. The vessel is now turning toward me – is that a mouth? My God, these things are alive!"

– Lt. Majid Asad, U.S. Space Navy

The biological spacecraft may be the most exotic example of biogadget technology in science fiction. This section deals with craft whose bodies are truly *alive,* as opposed to those that use only a few living, organic parts (such as a cyborg brain) or whose organic components are dead, such as wooden or plastic spacecraft.

Living ships are the result of taking a large alien life form (or less often, a big terrestrial creature), then using bioengineering to adapt it to serve as a space vessel. Often, they have been gengineered to make them even larger, by modifying their genes to increase growth hormone production.



The advantage of gengineering animals as spaceships, rather than as (for instance) water, ground or air vehicles, is that it is much easier to grow things to very large sizes in zero gravity.

While a living ship's body is, by definition, primarily biological, it may also be a cyborg, possessing inorganic systems that are grafted onto it. The TL required to create living ships depends on how much modification is needed to transform the original organism into a vessel; usually, the degree of genetic manipulation required is TL12+.

A suitable organism should be large (at least a dozen hexes in size and several tons in weight) and tough enough to hold pressure or atmosphere. It may or may not be intelligent. Ideally, it should also possess an organic space-propulsion system, but this may be too much to hope for in a "hard-SF" setting.

It's possible to have a humanoid bioship, but that's rather unlikely. More often, bioships resemble planetoids, streamlined whales, eels, spined sea-beasts, spider-crabs or even trees. Ship organisms in science fiction usually tend to fall into one of these categories:

Atmosphere Dwellers are alien life forms that resemble giant balloons or blimps (sometimes with tentacles). They might be found on any world with a dense atmosphere, including gas giants. Since they can already hold an internal atmosphere, they have some of the traits needed in a spaceship.

Giant Trees are bioengineered to adapt them into spaceships, and may be grown to enormous sizes in zero-G, inside greenhouse habitats or amid the life-giving gases of comets.

Marine Dwellers are huge, deep-sea animals like whales or – on a simpler level – coral reefs. The ability of underwater beasts to grow to great sizes and adapt to extremes of pressure makes them well-suited for use as bioships. While the actual use of Earth cetaceans might be impossible (or unethical), alien worlds might possess suitable whale-sized or larger critters, perhaps possessing additional useful traits like tough shells, tentacles or even bioelectric organs.

Vacuum Dwellers are natural space-faring creatures, sometimes even possessing their own form of organic stardrive. Some space-faring life may be too fragile or diffuse to make a good ship; e.g., living solar sails, plasmas or gas clouds. Other types might be very suitable, requiring only minimal modification.

Other types of creatures could also be modified.

Biomechanoids may have started out as any of the above, but have been turned into living machines. Protein-based components are used to create pseudo-alive controls, space drives, computers and other systems. In some types, the ship's body plays host to smaller, specialized organisms – a communicator-creature, a drive-creature and so on – all fused into one entity.

Propulsion systems for bioships may be mundane abilities, such as expelling internal gases for thrust or deploying a living solar sail. High-speed propulsion might be achieved through biomechanical or cybernetic space-drive implants – or even psi powers, such as a form of psychokinesis or teleportation that can move the ship, perhaps at faster-than-light speeds.

A bioship is normally somewhat cheaper than an equivalent spaceship, reflecting the fact that bioships can be bred or cloned. It can usually heal itself and requires little or no fuel or maintenance. However, it is generally more delicate (with less DR and fewer hit points) than inorganic vessels of similar size, due to the simple fact that flesh is easier to damage than machinery.

Bioship Design

Bioships can be designed as vehicles or robots, using the rules in ***GURPS Mecha, Robots*** or ***Vehicles*** for biomechanical structures, bioconvertor power plants and biomorphics. This is most appropriate for biomechanoid designs. Alternatively, they can be treated more like domesticated animals or alien races. This section has a "quick design" system for creating them in conjunction with the *Racial Generation* rules (pp. CI173-180).

ST and Size

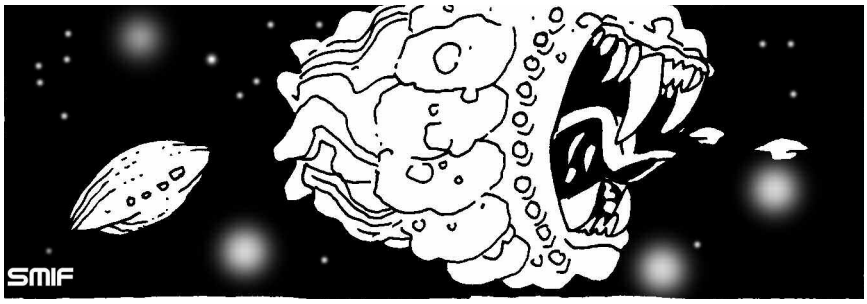
Bioships are usually very large, which means a lot of ST and Extra Hit Points. As a rough guideline, the table below gives a suggested ST (and its point cost) and weight in pounds for a ship of a given scale, where scale is how much larger (in all dimensions) the ship is compared to a human.

This table could represent the same species (small ships are babies, big ones are adults) or different species. It makes the assumption that big ships may be less agile but more intelligent.

As a general rule, ST (human average 10) increases with the *square* of scale, while weight (human average ~0.1 tons) increases with its *cube.*

Bioship ST and Size Table

Scale	*ST*	*Points*	*Mass (tons)*	*Notes*
5	+240	285 (171)	12.5	"fighter"
10	+990	660 (396)	100	"corvette"
20	+3,990	2,160 (1,296)	800	"destroyer"
50	+24,990	12,660 (7,596)	12,500	"cruiser"
100	+99,990	50,160 (30,096)	100,000	"battleship"
200	+399,990	200,160 (120,096)	800,000	"dreadnought"



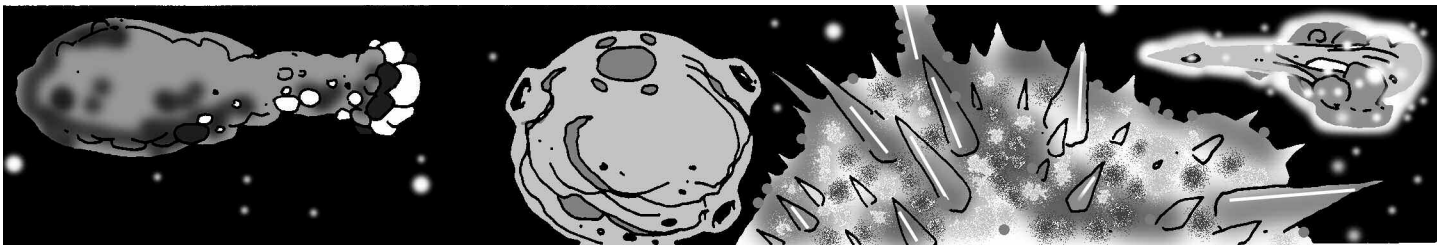
Scale: This is the size multiplier relative to human dimensions. See *Mass,* (below) for typical sizes of bioships.

ST: This is the suggested ST for that scale. Even if a ship has no manipulators, high ST is useful for pulling things, encumbrance, fatigue (for powering natural attacks and traveling long distances without rest) and even biting.

Points: This is the point cost for the listed ST, assuming the bioship has fine manipulators (e.g., arms or tentacles). If it doesn't, use the second point cost, which applies the No Fine Manipulators limitation (-40%).

Mass: This is the suggested mass in tons for the listed ST. A typical bioship has a volume of about 50 cubic feet times its mass; it might be five feet long times its scale, with a width and height of about one foot times its scale. Thus, a scale 200 bioship would be 1,000' long, 200' wide and 200' high. Big ships have lots of hit points (see below).

Notes: A rough guide as to the "class" of ship. This doesn't necessarily have to be a warship – a "battleship" could actually be a big trading or scout vessel.



DX, IQ and HT

Select whatever attributes are desired. Most bioships will have DX, IQ and HT in the 7-15 range. The exceptions are non-sentient vessels, like space trees, which often have DX 1 and IQ 1. It's suggested that these attributes not exceed TL+2. Ships that are larger have a lower DX but higher IQ.

Advantages and Disadvantages

The range of possible forms for bioships is nearly infinite, since they are usually gengineered from very exotic alien organisms to start with. Depending on what the original life form was, a bioship might have practically any advantage or disadvantage described in ***GURPS Basic Set*** or ***Compendium I.*** These may be due to a mix of inorganic or semi-organic implants, natural abilities and genetic engineering.

"Standard" Bioship Advantages and Disadvantages

Some advantages and disadvantages are more common than others. Just about every bioship will have . . .

• Damage Resistance (3 points/level, p. CI52). Bioships are usually thin-skinned, with DR in the 10 to 200 range; tougher ships often have some sort of biological force field (sometimes bought as Ablative DR or Absorption).

• Extra Hit Points (5 points/level, p. CI24). Bioships should buy Extra Hit Points so that the sum of HT plus HPs is neither less than half nor more than double their racial ST.

• Flesh Pockets. Each point buys a flesh pocket with a capacity of (ship mass/400) tons. A maximum of 40 points of flesh pockets are allowed. See *Flesh Pockets* (p. 136).

• Flight (40 points, p. CI56), often combined with Super Flight (20 points/level, p. CI67) or the Space Acceleration enhancement (p. 136). The Requires Low Gravity: 0 G (-50%) limitation (p. 138) is often applied to Flight for bioships that can only fly in space.

• Inconvenient Size (large, -10 points; p. CI102).

• Passive Defense (up to PD 6, 25 points/level; p. CI63).

• Subjugation (-20 points, p. CI105).

• Vacuum Support (40 points, p. CI70).

Other Common Bioship Advantages

These are among the most common bioship advantages. Few bioships will have them all, and many will have advantages that are not on this list:

Absorption (generic Energy, 10 points/level, p. CI49). Acceleration Tolerance (10 points, p. CI19).

Bio-Bomb (see *Bio-Bombs,* p. 102).

Chameleon (7 points/level, p. CI51. Enhancements: Affects radar or infrared, +50%; both, +100%. Limitations: Affects one of radar *or* infrared but *not* normal vision, -50%; affects radar *and* infrared but not normal vision, -25%). Combat Reflexes (15 points, p. B20). Compartmentalized Mind (50 points/level, p. CI52).

Doesn't Eat/Drink (10 points, p. CI53). Doesn't Sleep (20 points, p. CI53).

Eidetic Memory (30/60 points, p. B20). Extended Lifespan (5 points/level, p. CI54).

Full Coordination (50 points/level, p. CI56).

Hyperflight (requires Super Flight, 50/75 points, p. CI57).

Independently Focusable Eyes (15 points/direction, p.CI58). Infravision (15 points, p. CI58). Interface Jack (if it has built-in cyberwear, 10 points, p. CI26).

Laser (25 points + 6 points/extra die, p. CI73). Lightning (20 points + 6 points/extra die, p. CI73).

Peripheral Vision (15 points, p. B22). Psi Powers (see ***GURPS Psionics***). Psionic Resistance (2 points/level).

Radar Sense (varies, ships often have low-res radar, p. CI63). Radio Speech (25 points, p. CI64).

Sanitized Metabolism (5 points, p. CI65). Sense of Perception (100 points, p. CI65). Shock (20 points +6 points/extra die, p. CI73). Single-Minded (5 points, p. CI30). Spectrum Vision (40 points, p. CI66). Strikers (varies, p. CI66).

Teeth (sharp/fangs for 5/10 points, p. CI67). Telescopic Vision (6 points/level, p. CI68). 360-Degree Vision (25 points, p. CI68). 3D Spatial Sense (10 points, CI31).

Unaging (15 points, p. CI69). Universal Digestion (15 points, p. CI69).

Venom (usually a corrosive spit or spray, at 15 points/level with +35% to cost for spit or +100% for a spray cloud, p. CI71).

Webbing (20 points + 2 points/level, p. CI71).

Notes on Advantages:

Arms: Many bioships have no arms or legs. Those that do often seem to have tentacles, with extra hexes of reach (10 points/yard/arm, p. CI54) and Extra Flexibility (10 points for all arms, p. CI55). If a bioship has more than two arms, they are Extra Arms (10 points) sometimes with Modified Arm ST (p. CI61) to reduce ST relative to the body.

Internal Advantages: Special advantages can also be bought that apply to the *inside* of the bioship. A bioship is normally assumed to have no senses or manipulatory ability inside it. However, it can buy the following advantages to

manipulate internal cargo or passengers, perform repairs on cybernetic implants and the like:

Internal Arms or Strikers (1/5 the usual cost of an Extra Arm or Striker), Internal Hearing (4 points), Internal Sight (10 points), Internal Speech (5 points), and Internal Taste and Smell (1 point).

Enhancements to internal senses (e.g., Internal Discriminatory Smell), new internal senses (e.g., Internal Radar Sense) and internal weapons (e.g., Internal Venom) have 1/5 the usual cost. The reduced cost is *not* a limitation – these are different advantages, and actual limitations and enhancements can be applied on top of internal advantage point costs. E.g., to create "horror" bioships with the bad habit of accidentally digesting passengers (or intruders), buy Internal Teeth or Venom (corrosive) at 1/5 cost, *then* apply the Uncontrollable (-30%) limitation.

All of these costs assume the internal advantage is usable anywhere within the bioship. If it can only reach certain areas, this is a -50% limitation.

Weaponry: Many bioships are unarmed, or have cybernetic weapons (see below) or psi powers. A few are capable of generating some form of biological weapon, usually a laser, electrical discharge or some kind of corrosive venom (which can also represent hungry symbiotic bacteria, enzymes or nanomachines). For this sort of natural attack, either the "cheap" improvement scheme on p. CI72 or powers from ***GURPS Supers*** is recommended.

Other Common Bioship Disadvantages

These are among the most likely bioship disadvantages. Few bioships will have them all, and many will have disadvantages that are not shown here:

Anaerobic (-30 points, p. CI101).

Bad Temper (for warships, -10 points, p. B31). Bloodlust (for warships, -10 points, p. B31).

Disturbing Voice (-10 points, p. CI81).

Lame (legless, -35 points). Low Empathy (-15 points, p. CI91).

Impulsiveness (-10 points, p. B33). Invertebrate (-20 points, p. CI102).

Mute (-25 points, p. B29).

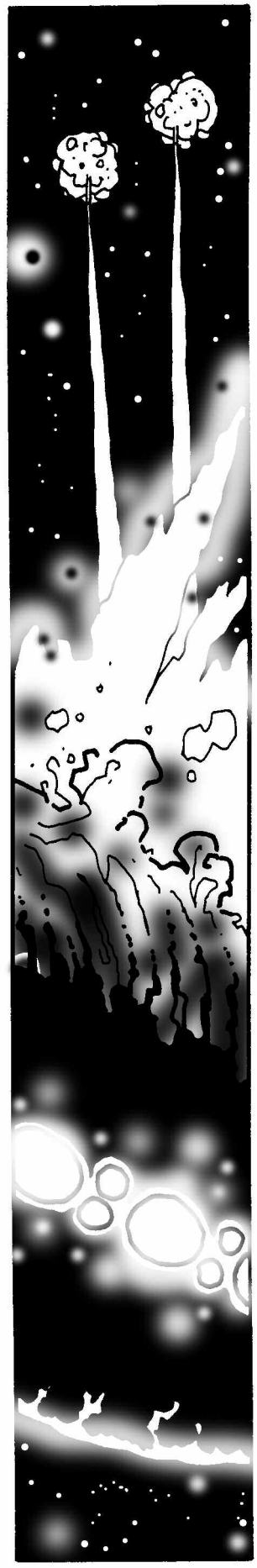
No Manipulators (-50 points, p. CI103).

Overconfidence (-10 points, p. B34).

Reduced Hit Points (-5 points/level, p. CI83).

Self-Destruct (-20 points, p. CI104). Sense of Duty (to master, -5 points, p. B39). Slow Metabolism (common among "space trees," -10 points/level, p. CI104). Sterile (especially for biomechanoids, -3 points, p. CI84). Stress Atavism (varies, p. CI105). Stuttering (unusual voice, -10 points, p. B29).

Weakness: Gravity (very common, p. CI106).



Notes on Disadvantages:

Initiative, Intelligence and Control: Ships that lack initiative, intelligence or free will usually have one or more of Hidebound (-5 points, p. CI91), Incurious (-5 points, p. CI91), Presentient (-20 points, p. CI103), Slave Mentality (-40 points, p. CI94) or Staid (-1 point, p. CI94).

A bioship usually has some kind of implanted physical or biotronic system to allow its master to communicate with and command it, especially if it is Presentient. If the bioship is near-sentient (Presentient and/or IQ below 8), commands will be similar to those one would give a riding beast. If it's sentient, commanding the ship will be more like giving orders to a subordinate.

If the ship requires a human at the controls in order to give it orders, Piloting skill can be used much like Riding skill; roll vs. skill to convince the ship to attempt difficult maneuvers. If the bioship requires a human at the controls to do *anything,* including traveling from point to point, it should be designed with Slave Mentality (*no* action unless master at controls, +100%, -80 points), and the pilot and any other crew will use their skills much as they would on any other spaceship.

Otherwise, crew members serve three purposes: to give the ship orders and make decisions (e.g., Leadership, Strategy and Tactics skill), to perform damage control (e.g., First Aid, Surgery and Veterinary skill), and to man and maintain cybernetic implants,such as weapon turrets.

Life Support: Despite their size, bioships rarely have Increased Life Support, since they are usually capable of providing for their own needs and those of their passengers internally.

Bioship Interiors

A bioship with flesh pockets has an internal area of about 1-4 hexes of floor or corridor space for every ton of mass (2,000 lbs.) the pocket holds. Most ships have sphincters in their body that serve as airlocks, opening up to provide access to their interior.

By sacrificing one ton of flesh pocket capacity, a ship has room for one passenger or crew member in short-term occupancy (a day or so, suitable for shuttles or fighters). For long term journeys, 5 tons' capacity can provide indefinite life support for one person.

Some flesh pockets may be furnished capsules implanted into the ship, their interior little different from any other spacecraft. Others may be disturbing places, with warm, fleshy walls, pulsing internal organs, writhing cilia and strong smells – after all, the occupants are occupying the insides of an enormous creature. Ships with Sanitized Metabolisms are nicer places!

Drones

Bioships occasionally have the ability to create and control organic drones – perhaps natural parasites that have been engineered into symbiotic life forms. These often help keep the ship's

insides clean and perform repair duties, and may also enable the ship to interact with human crew. Combat-capable drones could serve as a "macroscopic" immune system to repel boarders. A bioship may also carry much smaller drone bioships for use as shuttles, fighters or guided missiles (the latter should be built as Bio-Bombs, p. 102, or have a contact weapon like corrosive venom, bought with Limited Uses).

Bioship drones are best created as an alien race, usually with Mindshare (variable, p. CI60), Slave Mentality (-40 points, p. CI94) or both. They may count as an Ally Group (p. CI19) for the bioship, at the GM's option. Good fictional examples appear in George R. R. Martin's *Wild Cards: Aces High,* Walter Jon Williams' *Angel Station,* and Bruce Sterling's *Crystal Express.*

Transforms

In highly-cinematic ***Mecha*** or ***Supers*** campaigns, a bioship may possess the ability to transform into a much smaller "mundane" form. This is very convenient, since it allows a huge space battleship to hang around with other PCs. Buy this as the Transformation advantage (p. CI68). The best fictional example of such a vessel is Ryo-Ohki, from the multi-media series *Tenchi Muyo.*

Tech Level

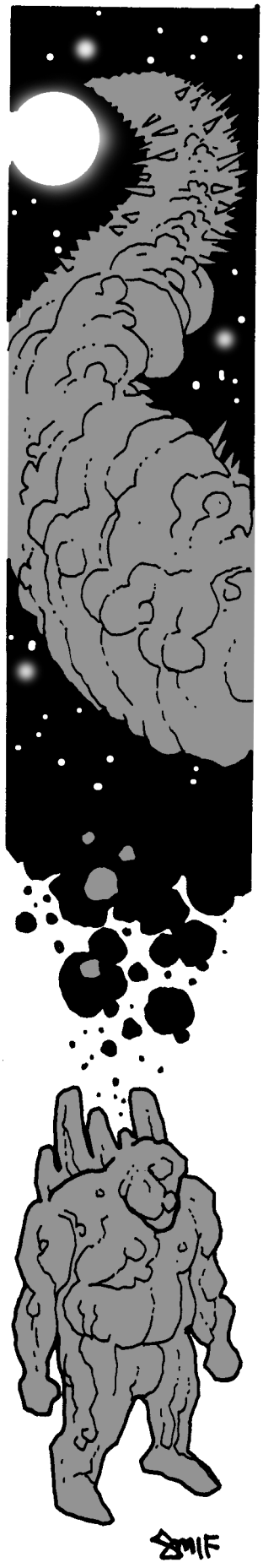
Bioships are usually at least TL12-13, but might be available at a considerably lower TL if a space-faring organism that is especially easy to adapt into a ship is utilized.

Gengineering Bioships: The level of gengineering required varies widely, especially since most of the more unique advantages (e.g., DR and Flight) may be innate to the species – this is why no TLs are assigned to them. If GMs want to use the gengineering rules to "game out" the design of a bioship, use the general guidelines for gengineering animals – that is, come up with the original species template, then apply modifications to it. Assume that any bioship advantage/disadvantage not native to the species and not mentioned in Chapter 2 requires TL14.

Bioship Cyberwear and Implants

Various weapons and gadgets – such as vehicle components – could be cybernetically implanted into a bioship, rather than being placed in flesh pockets. GMs may find it worthwhile to use ***GURPS Mecha, Robots*** or ***Vehicles*** as a source for possible equipment. If so, assume that the ship can have a maximum of 50 lbs. and 1 cf of new integral components per ton of ship mass. Where it matters – e.g., when adding armor or screens – assume that a ship's overall volume (*not* the same as the usable interior volume!) is about 50 cf per ton of bioship mass, and calculate surface area from there.

Implanted systems that can be controlled cybernetically by the ship itself cost an extra $500/system for neural interface wiring.



Purchase Price

Bioships may be priceless, but if they can be easily cloned or bred, a good way to estimate purchase price is to multiply final point cost by $1,000 (and add the price of any cybernetics). If bioships are much harder to produce (perhaps they must be captured wild and surgically modified), multiply the cost by a factor of 10 or more.

Sample Bioship: Voidshark (TL13)

ST +990 (396 points), DX +1 (10 points), IQ -3 (-20 points), HT +3 (30 points).

Racial Advantages: Acceleration Tolerance (10 points), Chameleon 4 (infrared and radar only -25%, 21 points), Combat Reflexes (15 points), DR 100 (300 points), Extended Lifespan 3 (15 points), Extra Hit Points +490 (2,450 points), Flesh Pockets (25 points, 6.25 tons), Flight (1 G space acceleration, +25%, 50 points), Hyperflight (75 points, 1 LY/day), Internal Hearing (4 points), Internal Speech (5 points), Internal Taste and Smell (1 point), Internal Venom (5 levels, corrosive, spray, +100%, 30 points), Lightning (60d, Costs Fatigue: 2/use, -10%, 337 points), PD 4 (100 points), Peripheral Vision (15 points), Radio Speech (25 points), Sharp Teeth (5 points), Spectrum Vision (40 points), Super Flight 4 (×16 move, 16 G acceleration, 80 points), Vacuum Support (40 points), Venom (20 levels, corrosive, spit, +35%, 405 points).

Racial Disadvantages: Bad Temper (-10 points), Inconvenient Size (-10 points), No Manipulators (-50 points), Overconfidence (-10 points), Sense of Duty (master, -5 points), Slave Mentality (-40 points), Sterile (-3 points).

Racial Cost: 4,336 points.

Price: $4,336,000.

The Voidshark was once a presentient water creature similar in mentality to a whale, but resembling a giant electric eel, with a tough, spiky hide and a mouth full of sharp teeth.

Over a period of centuries, the species has been bred and gengineered into a living spaceship: a corvette-sized (scale 10) bioship. A typical adult Voidshark is 50' long, 10' wide and 10' high, and masses 100 tons. Its skin has been toughened to resist vacuum and internal flesh pockets have been added. Electrical abilities and digestive enzymes have been tremendously enhanced to provide power to internal mechanisms as well as serving as weapons. A family of symbiotic biomechanoid organisms – a communicator beast, warp-drive beast and so on – have been implanted into its body to give it extra capabilities. All these modifications have left the Voidshark sterile – and bad tempered. It is controlled by internal mechanisms and a pilot.

The interior of the Voidshark is not pleasant; it is filled with pulsing organs, dripping ichor and odd smells. It has an airlock, several corridors and internal compartments (25 hexes worth). Its 6.25 tons of capacity are used to provide indefinite life support to the pilot and 1.25 tons of cargo space.

Sentient Buildings

"Yes, children, that cross-shaped building is our very own Dr. Raymond Garcia. His parents were Neo-Christian Hyper-Evolutionists, which is why he is a sentient biomass. Dr. Garcia is very clever, with six basic patents in his field just this year. Of course, we shouldn't be surprised, because his brain has a surface area the size our of swimming pool. Now, when we visit, we'll have to change and spray first, because Dr. Garcia doesn't want us tracking our germs inside his body."

– Carmen Ortega, school teacher

A near-sentient or sentient "living building" should be created like a bioship, but without movement abilities; use the Sessile disadvantage (-50 points, p. CI104). If it has arms, they are usually only internal ones. Many living structures have a more rectangular, squat construction than bioships – for instance, a typical house-shaped building might be 2' high, 2' wide and 1.25' thick times its scale.

Note that Sessile allows a -75% limitation on the cost of Extra Hit Points (see p. 138).

Dr. Garcia's Biomass

Here's a sample "living building." In Dr. Garcia's case, the goal was to produce a "new evolutionary stage" for humanity.

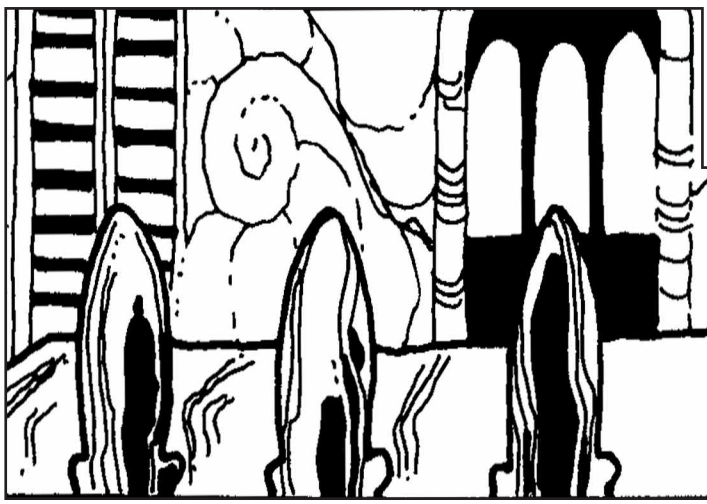
ST +990 (No Manipulators, -40%, 396 points), IQ +4 (45 points).

Racial Advantages: Extra Hit Points +490 (Sessile, -75%, 613 points), Flesh Pockets (10 points), Injury Tolerance (No Neck) (5 points), 360-Degree Vision (25 points), Unaging (15 points),Universal Digestion (15 points).

Racial Disadvantages: Inconvenient Size (-10 points), No Manipulators (-50 points), Sessile (-50 points), Unusual Biochemistry (-5 points).

Features: Scale 10, weighs about 100 tons.

Racial Cost: 1,009 points.



Other Living Structures

Spaceships and buildings are the easiest kinds of living structures to create. A living aircraft or land animal that is big enough that people can ride *inside* is trickier, because of structural problems associated with giant creatures. Gengineered submarines, watercraft or perhaps blimps are more feasible. Even though they *are* unlikely, feel free to create living aircraft or ground vehicles using these as models:

Bioblimps

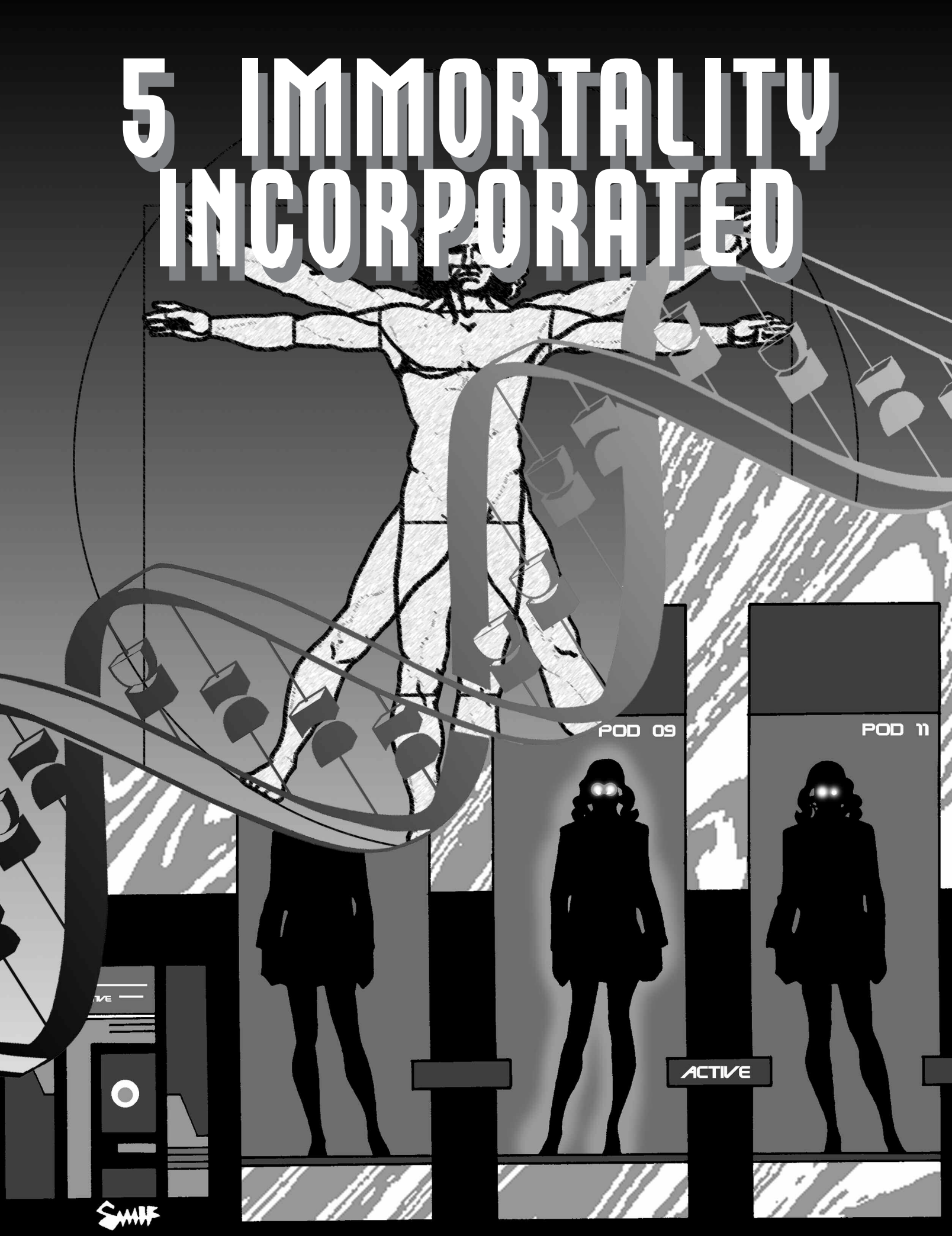
These remain buoyant due to hot air or hydrogen in internal sacs. They may drift in the wind, or be propelled by gas vents, wings or cybernetic implant propellers or jets. Some models have manipulatory ability – for instance, alien gas-secreting glands might be combined with cetacean or squid/octopus morphology and neural structures to develop tentacles (for picking up cargo or mooring . . . trunk-like tentacles could even siphon water for ballast or to drink).

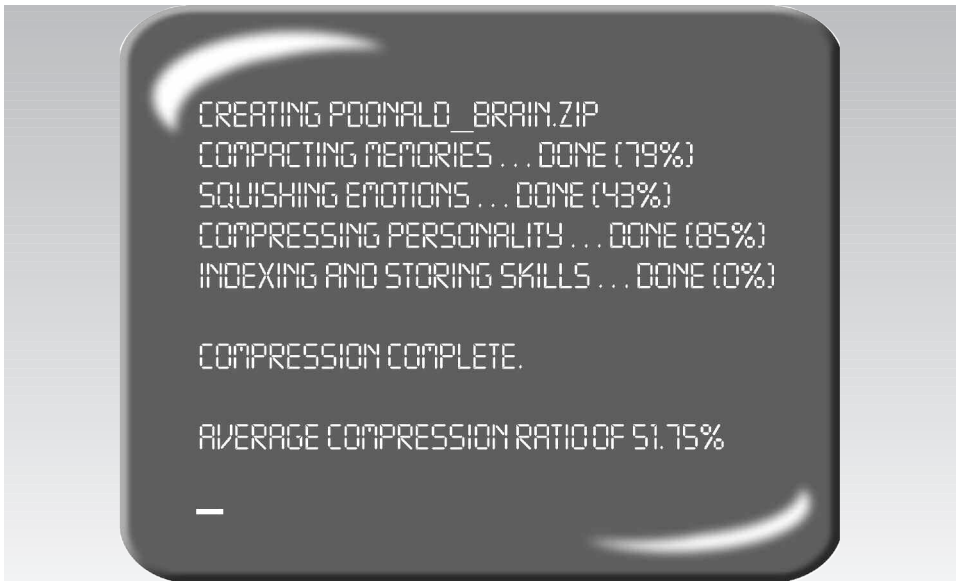
Bioblimps should be built as bioships, but limited to atmospheric flight. Vacuum Support and more than one level of Enhanced Move or Super Flight are inappropriate. Recommended disadvantages are Fragile (double penetrating damage from fire/heat rather than crushing attacks, -50%, -10 points; p. CI102) and Invertebrate (-20 points, p. CI102). Some bioblimps have Slow Eater (-10 points, p. CI104) or Slow Metabolism (-10 points/level, p. CI104). Due to the size of the gas bag, bioblimps will usually have a volume many times greater than their size would indicate, although weight remains the same and all of the extra volume is filled with stored gas and ballast.

Biosubs

These are gengineered water creatures, usually propelled by flippers, a fluke or tail, or a squid-like jet. Build these like bioships, but without Flight and Vacuum Support. Suggested advantages are Enhanced Move (Swimming) (10 points/level, p. CI54), Gills (0 points, p. CI56), Pressure Support (varies, p. CI63) and Sonar Vision (25 points, p. CI66). Aquatic (-40 points, p. CI101) is the most common disadvantage. Naval biosubs often possess tentacles, bioelectric weaponry, an ink jet (Smoke, only in water, -30%, 11 points; p. CI73), or small, fast drones with the Bio-Bomb advantage that can be used as torpedoes.

5 IMMORTALITY INCORPORATED





Braintaping. Suspended Animation. Cryonics. These are all processes whose fundamental goal is to outsmart death in one or way or another. This chapter takes a look at the methods involved and their implications, as well as offering alternative ways of handling these technologies in different campaigns and settings.

Cryonics and Suspended Animation

The goal of these processes is to use a combination of cold and drugs to slow down or stop biological activity in humans, while doing as little damage to the body as possible.

Cryonic Preservation (TL7)

Cryonics is the practice of preserving recently-dead bodies at extremely low temperatures, with the hope that future medical science – especially nanotechnology – will be able to revive them. At present, there are a handful of corporations or societies devoted to cryonic preservation, mostly in the United States. Only dead people are frozen, as TL7 cryonic techniques would kill a living subject.

If cryonic preservation is to be meaningful, it must take place as soon as possible after death. This is because a dead body's tissues suffer ischemic damage (progressive deterioration that sets in after breathing and blood circulation cease). Patients should be placed on a portable heart/lung machine immediately after clinical death, to restore some circulation. Their corpses can then be taken to a cryonics facility, where the actual cryonic process can take place.

Preservation at cryogenic temperatures prevents further tissue deterioration, but has its own problems. The most significant of these problems is caused by ice crystals forming in the cells. The human body, even dead, is mostly water. When it is frozen, the water expands, rupturing the cells. This can cause cracks throughout the body, including the brain.

To minimize tissue damage, a special protective solution (at TL7, a glycerol-based solution) is slowly introduced into the subject's tissues, using a specialized heart/lung machine to pump it through the patient's body. The patient's brain is carefully monitored during the process, which takes about four hours. Next, the patient's temperature is gradually lowered (over the period of five days) using dry ice. When cold enough, he is then deposited in a liquid-nitrogen bath for permanent cryopreservation at -320°F. At this temperature, all biochemical and metabolic deterioration effectively halts. Subjects who are maintained at this temperature can be preserved almost indefinitely.

A person in cryonic preservation is sometimes called a "corpsicle" (a term coined by SF author Larry Niven), a term that advocates of cryonics may consider to be impolite.

Age and Aging

In the developed countries, the population is fast approaching the point where senior citizens will be the majority, and far less likely to "retire" quietly from the scene.

GURPS currently reflects aging by a progressive decline in attributes when "aging rolls" (vs. HT+TL-3) fail; see p. B83. Normally, an aging roll that comes up 17 or 18 results in the loss of *two* attribute points. This is a perfectly valid approach, but it can be made a little more colorful: Starting at age 60, aging rolls that come up 17 or 18 cost only *one* point from an attribute, not two. However, on a natural 17, also roll for a disadvantage on *Table 1;* on a natural 18, roll on *Table 2.*

Table 1: Age-Caused Disadvantages

1 . . . . Appearance*
2 . . . . Bad Sight
3 . . . . Extra Sleep (one level)
4 . . . . Hard of Hearing
5 . . . . Hidebound *or* Obdurate
6 . . . . Extra -1 to attribute

* Lower Appearance by one step; e.g., Attractive becomes Average, or Average becomes Unattractive. Do not reduce Appearance below Unattractive.

Table 2: Severe Age-Caused Disadvantages

1 . . . . Absent-Mindedness
2 . . . . Short Attention Span
3-4 . . Terminally Ill (-50 points)
5 . . . . Weak Immune System
6 . . . . Extra -1 to Attribute

If a pre-existent or inappropriate disadvantage is rolled, either reroll or assume two attribute points are lost. Bad Sight or Hard of Hearing can be allowed to progress to Blindness or Deafness, additional levels of Extra Sleep can be accumulated, and Terminally Ill can progress up to -75 and -100-point versions, if the GM wishes.

Gaining a disadvantage from old age does not "give back" any character points. Instead, reduce the character's point total. Likewise, characters who acquire disadvantages in this manner do not have to pay points to buy them off – GMs should allow this for "free" if the character goes to the expense or effort of finding effective medical treatment. GMs should define Terminally Ill as a specific disease, and allow treatment on that basis.

More About Cryonics

Since cryonic preservation costs $50,000-$150,000, an up-front payment is out of the reach of most people. One solution practiced by current cryonics corporations is to encourage their customers to take out life insurance policies, payable to the corporation. For a few dollars a week, immortality may be yours.

Most cryonics companies take great pains to ensure their financial stability, investing a portion of all fees in trust funds. (This gives a new meaning to the term "brain trust"!) These precautions are to ensure they can maintain their patients and, hopefully, will have the funds to pay for whatever medical procedures prove necessary for future revival.

However, there's always a chance that something may go wrong. Besides the obvious problems of fly-by-night operations and the possibility that future science may not be up to the task of resurrecting people, here are a few other scenarios:

Financial Disaster: Someone goofs (or the entire national economy collapses!) and the organization runs low on money. It's possible that whole-body preservations may be converted to cheaper-to-maintain neuropreservation, or that some or all bodies may have to be allowed to thaw.

Problems with the Law: Preserving corpses "without decent burial" rubs some people the wrong way. Currently, most cryonics firms have good lawyers and emergency plans. But if laws or morals change (for example, in the neo-fascist ***GURPS Cyberworld*** setting), they could find themselves having to look for new homes in a hurry, and maybe hiring some professional help. Smuggling a dozen steel containers out of state may be an interesting challenge for a group of street ops, especially if each holds a ton or so of liquid nitrogen and a dozen human heads.

Future Nightmares: Future society may have lucrative and unpleasant uses for "corpsicles" – e.g., reviving the brain, only to incorporate it into a cyborg starship or computer matrix. In several of his stories, author Larry Niven has suggested that if freezing techniques become good enough to preserve bodies without much tissue damage, then a future society might look upon cryonauts as a potential source of organ transplants.

A typical price for "whole-body" cryonic preservation, including both the operation itself and the promise of indefinite cryonic storage, is $150,000. But there's a cheaper alternative . . .

Neuropreservation

This process involves preserving only the severed head (since the brain is the seat of memory), the idea being that a technology advanced enough to revive a body should be able to handle a brain transplant to a clone. Neuropreservation is cheaper, since a head is smaller. On the other hand, this kind of "head job" is controversial, for a couple of reasons. First, many consider the practice a little ghoulish. Second, it's possible that a future society might have ethical qualms about transplanting a brain into another body (even a clone), or might not consider a severed head to be worth reviving. Neuropreservation (including operation and storage) costs about $50,000.

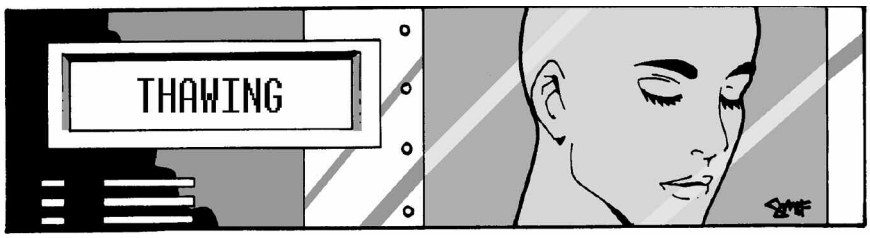
Cryopreservation Units (TL7)

These storage units are basically giant thermos bottles designed for very low temperatures. They don't require electrical power, instead relying strictly on chemicals. Since they are intended for the long haul, cryogenic preservation units are normally made of two layers of steel separated by multiple layers of insulating material. This reduces evaporation to a minimum, but they should still be topped up with liquid nitrogen every 10 days or so. In an emergency, they can be left untended for a few months before the bodies will begin to thaw. Bodies are usually stored head-down so that the brain will remain cool even if there is some evaporation.

At TL8, cryopreservation units are more efficient, requiring replenishment only twice a year.

Whole-Body Unit: A storage unit designed to preserve 3-5 whole bodies. 2,000 lbs., 40 cf, $10,000.

Neuropreservation Unit: A storage unit designed to preserve 10 heads. 1,200 lbs., 12 cf, $6,000.



Cryonic Revival (TL9)

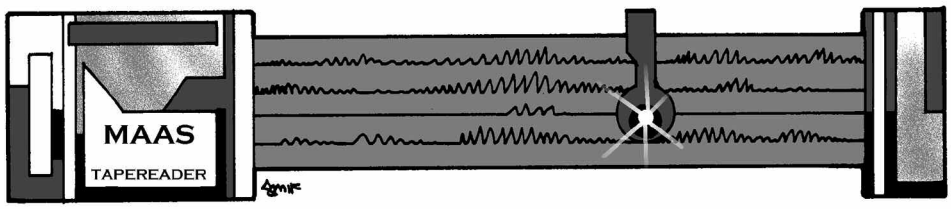
A "corpsicle" frozen using TL7-8 cryonic preservation techniques may be brought back to life with the help of advanced nanotechnology. Here's a possible schedule for revival:

TL9: A corpsicle's body can't yet be brought back to life. However, cell samples are well-enough preserved to allow a clone to be made. That clone won't have the original's memories,but the preserved brain's deep structure can be read using braintaping technology (p. 116), and that braintape can then be transferred to the clone. Unfortunately, the primitive freeze techniques used mean only a *very low-res* braintape can be retrieved (p. 117) using this technology.

TL10: More advanced memory salvage processes mean that *low-res* braintapes (p. 117) can be made from corpsicles.

TL11: Normal braintapes are now possible. At this point, anyone who was frozen can be "brought back to life." Of course, the result is a copy rather than the original.

TL13: The original body can be restored. The body is placed in a chrysalis machine (p. 23), where advanced nanomachines will thaw it out, place it in a form of bio-stasis, and then repair any damage or disease suffered. This process takes about one day for every hit point the corpse was below 0 HT at the time it was frozen. Since the body is being virtually rebuilt anyway, it's relatively trivial to also restore any losses that occurred due to aging.



At any TL, if the brain itself was badly damaged by injury, radiation or illness *before* freezing took place, the new body may be missing the memories or personality of the original. See *Braintaping* (p. 116), for the limitations.

Suspended Animation (TL9)

Being able to revive a frozen corpse is one thing, but freezing people without killing them requires a far more advanced technology. This process is "suspended animation," sometimes called "bio-stasis" or "freeze." The suspended animation chamber, or "freeze tube," uses a combination of cold and drugs to preserve the occupant, often with automatic drug dispensers built into the tube itself so that a person need only lie down and close the tube to be put into freeze within minutes. The "freeze drugs" used may be advanced versions of current cryo-protective drugs, or biological nanomachines.

Whatever the means, a *live* person who has undergone suspended animation is *not* dead. Rather, his metabolic processes have been effectively halted, but can be restarted using the machinery contained within the suspended-animation chamber. In this way, an injured or dying person can be preserved, perhaps long enough to reach a medical facility that can cure him. If no cure is available, he can be frozen between life and death until future science can devise one.

The obvious non-medical use of suspended animation is for space travel. If a space voyage takes years, suspended animation may be necessary for manned flight. Even if it takes weeks or months, it would still reduce tedium and save on life-support costs.

Healthy people may also choose suspended animation to "time travel" into the future. The motive could be unwillingness to wait for an event ("wake me up when you're ready to marry me"), boredom ("wake me up in a hundred years") or even a desire to monitor a long-term process, such as a team of sociologists monitoring a culture's development ("wake me up when the Tang Dynasty falls").

Individuals – or entire organizations – who live only for a specific mission may be kept in suspended animation most of the time, being revived only when needed. For instance, a super-assassin or an entire army of bio-soldiers could be too dangerous or expensive to maintain in peacetime. Instead, such individuals could be kept in suspended animation, to be thawed out and briefed whenever a crisis threatens, then put back to sleep afterwards. (This might make an interesting campaign, as each adventure could be set progressively farther into the future.)

Finally, a *dead* person kept in suspended animation can be more easily braintaped. If cloning and memory transfer are feasible, a freeze tube will keep the body "on hold" until a clone can be prepared. The occupant will not deteriorate until 1d hours after removal. Suspended animation is also useful for keeping spare bodies on hand (see *Cloning of Multicellular Organisms,* p. 14).

Freeze Tubes (TL9)

Putting someone into freeze or taking him out takes one hour. Unlike nitrogen-based cryopreservation units, freeze tubes are electrically-powered, with a built-in E cell for backup. A freeze tube can run on this backup power for six months at room temperature. No other maintenance is needed. Freeze tube storage costs $250/day for short periods, or $50,000 annually; discounts of 10% to 60% off the annual fee are available for long-term storage of 50 years or more. This price includes a very safe, well-guarded storage space.

A freeze tube, with dedicated monitoring computer, costs $55,000. Weight is 750 pounds and volume is 50 cubic feet.

Braintaping Fees

At TL9+, many commercial clinics that have clone facilities also have braintaping equipment, and vice versa. Here's a typical schedule of fees that would be charged by a hospital or similar organization, assuming that braintaping is perfectly legal:

• $2,000 to direct-program a blank-minded clone, whether for the first time or with a memory update. The clone will cost extra – see *Cloning Costs and Times* (p. 16).

• $25,000 to make a braintape copy on MMSD or digital media, or to update such a braintape with more recent memories. This price drops to $12,500 at TL10, or $6,250 at TL11.

Memory Storage

We are our memories – but while memory is known to be seated in the cells of the brain, its exact workings are still somewhat mysterious. According to current theories:

Short-term memory is stored electrochemically, and is not durable. Within a few minutes to an hour, short-term memories are either forgotten or transferred into long-term memory. In addition, trauma (especially a head injury, and probably death followed by braintaping) may result in short-term memories being lost. This means that someone who is revived via braintaping will often have no memory of the last moments of his life!

Long-term memory consists of those memories that our brain has permanently retained, by accident or design. Long-term memories seem to exist in the structure and connections of the brain cells themselves. As long as the brain has not suffered substantial damage, this should survive for a few hours after death, until the brain cell membranes themselves begin to decay. Specialized freezing techniques (cryonics or suspended animation) may be able to preserve these structures indefinitely.

Braintapes and Realism

Earlier ***GURPS*** books made certain assumptions about braintaping. Now that current advances in fields such as nanotechnology are beginning to suggest ways in which braintaping may be accomplished, GMs may wish to correct some of these assumptions in light of current thinking on the subject. These optional rules can be used to make braintaping "more realistic":

Fading Memories: The direct programming rule (p. 116) assumes that memories will fade from a clone if they aren't updated periodically. Actually, there's every reason to believe that long-term memories, once programmed, would be permanently stored.

Freezing: The idea that freezing a corpse will buy extra time to make a braintape doesn't hold up realistically. Unless cryonic or suspended animation technologies were used, freezing will damage the brain, making 'taping harder!

Memory Requirements: The figure of 100 gigs for a digital braintape is terribly optimistic – 100 *terabytes* (100,000 gigs) is more realistic. On the face of it, this means that braintapes would require sizable data banks to store them, especially at TL9-10, and putting braintapes on standard computer disks (as in ***GURPS Ultra-Tech's*** personality implants) would require TL14, not TL11. However, earlier books seem to have underestimated the data storage capabilities of ultra-tech computer media by about the same factor – see *DNA Computers* (p. 13). Thus, if both optional rules are used, we're back to minds-on-disk again.

Progressive Deterioration: While memories may survive for hours after death, there may be some losses. Optionally, if more than 2 hours have passed since someone's death, only low- or very low-res braintapes are possible, and after 12 hours, only very low-res brain tapes can be recovered. This assumes that the subject isn't preserved via cryonics or suspended animation, of course.

Braintaping

Braintaping is the process of copying of a person's mind ("memory and personality") into some form of physical or electronic storage matrix. The usual goal of braintaping is to achieve a form of serial immortality. Once a body is badly damaged or dead, the braintape can be transferred to a new matrix, often a blank-minded clone of the original. If this process is carried out properly, the new receptacle then becomes the mental duplicate of the original person. Depending on the technology, it may also be possible to store copied minds ("braintapes") in a physical or electronic medium so that the transfer can be made later.

Memories appear to be encoded within the physical structure of the brain on the molecular level. The problem in braintaping is twofold: first, to copy *all* this information in a usable form (that is, to make a complete blueprint of memory, not just a photograph). Second, to use this copy to reconstruct the original's memory and personality within a new host.

This section presents several alternative forms of memory-transference technology. Exactly which ones are in use in a particular campaign is up to the GM. Likewise, the TLs are completely up to the GM – there's no reason why braintaping should not occur much later than TL9, the level that previous ***GURPS*** books have set for it.

Braintaping Techniques (TL9)

Braintaping is the standard method of memory copying and transfer in ***GURPS.*** It assumes that it is possible to make quick copies of a mind without damaging the original or causing significant memory loss in the process.

Molecular scanning of the brain might use an advanced form of magnetic resonance imaging (MRI), or some other form of non-invasive scanner. However, it's also possible that the precise imaging required may require actual physical probes. These might be a development of the scanning, tunneling microscope (STM – a device currently being used to study and manipulate molecules), or they may be artificial microorganisms or robotic nanomachines which replicate through the brain, mapping it. Such nanobots might be designed to transmit information back after they have permeated the brain, or it may prove necessary to send in other nano to gather data from them. It's also possible that nanobots would work in concert with external sensors; e.g., the nano might "highlight" areas of the brain (perhaps with isotopes) in order to make external scanning easier.

If invasive brain probes are used, they should be designed so that they do not disturb brain structures as they record them. Memory transfer probably involves the use of similar active probes, but this time they would be designed to alter molecules. Programmed with the information gained during the copying process, they would rewrite the host's brain structures to conform to the original's.

Here's how it might work in practice:

Direct Programming (TL9)

Direct programming is the process of mechanically copying all memories from a person's brain to the brain of his blank-minded clone. This does not require the actual storage of memory. Instead, the molecular probes being used to read the memories of one brain are directly linked to similar probes being used to program the other.

This can be visualized as two machines joined by a cable, one for scanning, the other for programming. The original person lies in one machine, the clone in the other. The scanner reads the original's memory and immediately transfers the data to the programmer, which writes it into the other brain. There is no need to translate the analog data gathered by the probes into a digital medium – it's simply going from one biological matrix to another. If internal probes were employed, the actual probes themselves might even be transferred.

From the patient's point of view, he simply visits a clone storage facility and programs his (comatose) clone with his memories. This takes one hour. If not reprogrammed within a month of the previous visit, the clone's mind will go blank again. See *Cloning Costs and Times* (p. 16) for the cost of growing and maintaining a clone in storage.

It is also possible to program a clone from the original's recently-dead body. If successful, the reawakened clone retains all the original's memories up to his time of death. While the exact moment of death will often not be recalled, circumstances leading up to it (e.g., a mortal wound or illness) can be very traumatic. Unless death was either peaceful or sudden, the GM can require the clone make a successful Will roll to avoid acquiring an appropriate new Phobia (p. B35) from their death experience.

Direct programming from a corpse must be done within 24 hours of death. Sticking the body in a freezer will give up to ten days – but see *Braintapes and Realism* (p. 116) for some optional rules. Cryonic preservation (p. 113) or suspended animation (p. 115) techniques allow indefinite storage before braintaping, although cryonic preservation imposes some limits – see *Cryonic Revival* (p. 114). The body must also be relatively intact (no worse than -5×HT) and the brain must be in decent shape. More than 5,000 rads of radiation damage (+1,000 rads per TL over TL9) will prevent braintaping, as nerve tissue will be damaged beyond readability.

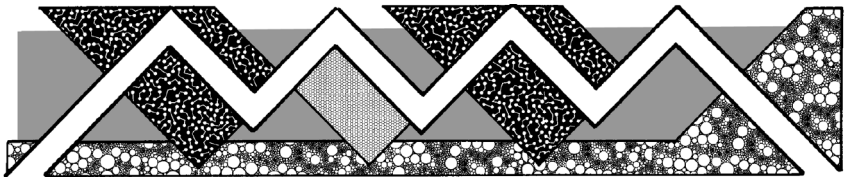
Braintapes (Late TL9)

Rather than being stored in a clone, memories are recorded in a mechanical matrix, as a "braintape." This is a non-trivial task, but has the advantage that no clone need be kept in storage (just whatever cells are needed to grow it). Furthermore, multiple copies can be made as safeguards.

TL9 braintapes can only be stored within a *mechanical memory storage device* (MMSD): a large, specialized device that stores one person's braintape. Unlike a digital braintape (below), this is an analog memory storage device – possibly a semi-organic, protein-based matrix – which would explain why it is larger and heavier than a digital braintape. See *Braintaping Equipment* (p. 119) for MMSD weights and costs.

TL10+ techniques store all of a person's memories indefinitely on standard computer media ("on disk"). This requires converting the brain's analog memories to a digital format. For game purposes, assume 100 gigabytes of storage space is required for a person's memories, allowing for data compression.

While a MMSD or computer disk can be stored anywhere, updating it with more recent memories requires a special *clinical braintape machine* or *portable braintaper* (usually found only in hospitals), and requires a two-hour session. See *Braintaping Equipment* (p. 119) for details.



Low and Very Low Resolution Braintapes (TL9)

These are "quick and dirty" copies of an individual's mind. A clinical braintape machine or portable braintaper can make a "low-res" braintape at +2 to skill for 50% of the normal time and cost, or a "very low-res" braintape at +4 to skill for 25% of the normal time and cost. If stored digitally, a low-res braintape takes only 1/2 the storage space; a very low-res one takes only 1/5 the space.

Alternative Braintaping Technologies

Here are some options that change the way braintaping works in a campaign:

Brainpeeling

What if it were impossible to make a molecular copy of the brain without harming it? If the brain is being mapped by nanomachines, they might destroy the brain's structure even as they record it. After a braintape copy is made, the original person is very dead, but the copy still exists. If it's a digital copy (TL10), this means that multiple copies can still be made.

Custom Brains

As memory is built into the structure of the brain cells, it may prove impossible to simply write memories onto the brain of a "blank-minded clone" or other person. If this option is used, instead of transferring memories to an existing clone, it will be necessary to *grow* the clone brain, layer by layer, to match the "taped" information. This takes the same time as growing the rest of the clone (and can be done concurrently). This also means that updating the memories of a "ready to use" clone would be impossible – you'd need an entirely new brain.

Low- or Very Low-Res Only

It's possible that braintape technology isn't quite up to making a completely accurate model. If so, then normal braintape machines all produce low-res copies (at the same cost, time and skill as a normal braintape), low-res machines produce very low-res copies (at the same cost, time and skill as a low-res braintape) and very low-res machines do not exist.

No Digital Braintapes

Braintapes can only be stored in a special MMSD matrix. This means that they can't be copied over and over again, or used in ghostcomps, making it easier to ensure someone "stays dead."

Persona-Napping

Someone who wants to abduct a person in order to interrogate, hire or enslave him may find it easier to copy a braintape and steal tissue samples than to abduct the original. If done properly, no one – including the original – may be aware that a crime has been committed.

This crime may be very easy to commit tracelessly if the perpetrator is an official in charge of a braintaping clinic or other body that has been entrusted with such samples. Discovering that a copy of you has been made and is in someone else's hands, possibly suffering abuse, may be a very traumatic experience.

Multiple People

Braintaping or similar technology can create multiple copies of the same personality, in cloned or different bodies.

In general, the GM should let a player control only one of them. The others will diverge into different people. The GM should play them much like the original, but they will develop their own goals as they have diverse experiences – this can happen right away, if they learn that they aren't unique. In fact, a copy (or the original, if he learns he's been braintaped) may deliberately *want* to alter his lifestyle in order to better express his own individuality.

If the original dies, the GM can allow the player to switch to another copy (West End Games' ***Paranoia*** RPG was built around the humorous possibilities inherent in this idea). Alternatively, the GM can rule that the player character is dead and the other clones remain NPCs. This is suggested if the copies have had time to diverge considerably in terms of their life experiences.

Depending on their personalities, two "duplicates" (regardless of which is the original and which is the copy) may get along, be uncomfortable with each other, or be unable to stand the sight of one another. However, they will have a close bond, and will think in much the same way – if they are together, they may astound observers (and themselves) by finishing each others' sentences, and will have close insight into one another's feelings.

Continued on next page . . .

If a *low-res* braintape is used to program a clone or is played into another body, it's treated as a normal braintape, but there's a loss of skills and memories. All points put into skills are halved (round fractions of 1/4 down to 0), reducing levels accordingly. In addition, the subject will often experience partial memory losses. The subject should make an IQ-3 roll. If the roll fails, Partial Amnesia (-10 points, p. CI86) results; on a critical failure, Total Amnesia (-25 points, p. CI86) occurs. The subject also has a 50% chance of gaining Flashbacks (-5 points, p.CI90), representing the brain struggling to make links to isolated pockets of memory.

If a *very low-res* braintape is used to program a clone or is played into another body, it's treated as a normal braintape, with a *significant* loss of personality, skills and memories. The copy has -2 IQ and Total Amnesia (-25 points), but retains a basic personality (including mental advantages and disadvantages), his life skills (including native language at his new IQ) and 1/4 his points in skills (round down). However, advantages based on emotional sensitivity – e.g., Charisma, Empathy, Fashion Sense, Rapier Wit and Sensitive – are lost. The subject has a 50% chance of gaining Flashbacks (-5 points), as above.

Game Effects of Braintaping

Braintaping is almost totally reliable if performed with proper hardware of the sort found in major hospitals.

If the GM cares to roll for hospital braintaping, use Electronics Operation (Medical) skill; a typical specialist would have this at skill 1d+13. A normal failure simply results in a delay of 2 hours or so; a critical failure must be confirmed by a second failure before an undetected problem can occur. This may range from the wrong braintape being played into the body to a damaged or flawed transfer, as described under *Portable Braintaper* and *Portable Programmer,* below. Statistically, a clinical braintape machine can still make mistakes in an extremely small percentage of cases – this could lead to an adventure, especially if a hospital tried to cover up its error.

If a clone is activated after being programmed via direct memory transfer or a braintape, it gains the memories and skills of the original as of when his memories were last recorded or transferred. If the new body's statistics differ from the old one's (e.g., an old man transferring into a young clone body), adjust as for *Brain Transplants* (p. 66). A recent transferee has DX-6 and IQ-2 as the mind adapts to the new body. Make a HT roll every week: success regains 1 point of each, while a critical failure is a temporary setback that *costs* 1 point of each.

For ethical (and possibly technical) reasons, braintaping is designed to be used on a "blank mind" – usually, a clone grown while comatose, which has no memories of its own. Programming an awakened person (including a clone who has had experiences of his own) with a braintape may either completely overwrite his mind (creating a new person), rearrange brain cells so as to leave him a vegetable (IQ 1), or result in an unstable blend of both minds – GM's option. If the latter, assume the effect is a Split Personality (-10 points), with -10 to -30 additional points of *different*

mental disadvantages for each personality. Edgy, Flashbacks, Manic-Depressive, On the Edge and Paranoia are all appropriate.

At the GM's option, TL10 technology may allow a braintape to be played into a blank-minded clone of *someone else.* If this happens, use the braintape's IQ, skills and mental advantages and disadvantages, but the ST, DX, HT and physical advantages and disadvantages of the clone body. Adjust all skills to conform to the new DX of the body, and adjust IQ by any species modifiers. For example, if a human mind were played into an ordinary dog's body (IQ 5), the human would be -5 on IQ. However, while any decrease is possible, IQ can't *increase* by more than +2 in this way. Recalculate character point totals based on the new values.

Braintaping Equipment

There are numerous different types of braintaping and braintaping-related equipment.

Direct Brain Programmer (TL9)

This is a machine that can directly program the brain of a blank-minded clone with someone's memories and personality. It *cannot* store memories on a MMSD or disk. The process requires the original and the clone (who may still be in the clone tank) to be present and hooked up to the device. The transfer takes two hours and requires Electronics Operation (Medical) skill.

A direct brain programmer is 1,000 lbs., 40 cf and $200,000. Halve weight and cost at TL10, and again at TL11.

Clinical Braintape Machine (Late TL9)

This is a hospital-quality device for braintaping. It resembles a double-sized life-support bed with specialized, sophisticated cerebral scanning and diagnostic facilities built into it, plus cables to connect to a MMSD or data bank. It is designed to be as safe and reliable as possible.

A clinical braintape machine can record braintapes from a living person or recent corpse as described above, imprinting them into a blank-minded clone or MMSD, or (at TL10+) storing them in digital format. It can also transfer memories from a MMSD or (at TL10+) digital braintape into a blank-minded clone. Either way, the process takes 2 hours and requires Electronics Operation (Medical) skill.

Braintaping installations at hospitals are almost totally reliable, with numerous safety interlocks and computerized tutorials. (If the GM cares to roll for hospital braintaping, a critical failure should require a second roll, with only another critical failure "confirming" the error. Failure can have some of the effects described for failure with portable braintapers and programmers, below – GM's option.)

A clinical braintape machine is 2,000 lbs., 40 cf and $1 million. Halve weight and cost at TL10, and again at TL11. A *low-res* clinical braintape machine (which can *only* make low-res braintapes – see p. 117) is half the normal price.

MMSD (Late TL9)

This is a mechanical memory storage device, used to store a single TL9 braintape. (At TL10+, memories are usually stored digitally.) It weighs 800 lbs., takes up 54 cf and costs $40,000. If no digital braintapes exist, higher-TL MMSDs may get smaller. At TL10, a MMSD may be 1/10 weight and half cost. At TL11+, it might resemble a large video-game cartridge (8 lbs.) and cost $10,000.

Multiple People (Continued)

In game terms, this can be expressed by giving each of them some or all of Empathy (only with duplicate, -70%, 5 points; p. B20), Intuition (only to guess what duplicate plans, -70%, 5 points; p. B20) and (in some settings) Special Rapport (p. CI46). If the original was telepathic, the copy will be also. Furthermore, it's likely that their minds will be synchronized. The GM may allow both characters to buy the Mindlink advantage (p. CI41), perhaps allowing one level per level of Telepathy Power they have.

The point value of these advantages can be reduced by taking any of these disadvantages: Easy to Read (only by duplicate, -70%, -3 points; p. CI89), Jealousy (only toward duplicate, -70%, -3 points; p. B34) and Paranoia (that duplicate is plotting against you, -40%, -6 points; p. B35). The limitation on Paranoia is worth less because the mental double doesn't have to be present for the original to be worrying about what it might be doing! The GM can also consider the possibility of one duplicate counting as an Evil Twin (p. CI77)! These disadvantages must be bought off if all mental duplicates are destroyed, comatose or otherwise disposed of.

Campaign Effects of Braintaping

When a clone is "activated" after the legally-proven death of the original, most societies consider the clone to legally *be* that person, with all his rights and property. Societies may pass laws to restrict multiple copies of living people, though some may allow it (creating a "clone family" effect). To maintain control, some societies may build braintapes so that copying them automatically erases the first tape, and pass laws to prevent multiple copies of living individuals from being made. Braintape recording and clone growth will be strictly supervised by such governments, though bootleg labs will exist.

But what does braintaping mean to adventurers?

Continued on next page . . .

Campaign Effects of Braintaping (Continued)

First and foremost, they can *never* be sure that someone is permanently dead. Cell samples can be frozen; braintapes are easy to hide. Even if a foe is legally dead, and no longer has access to his money or property, he can return to haunt them. As a result, assassins and kidnappers would try to destroy or steal braintapes as well – maybe even first. This also applies to the PCs themselves; it is quite possible their enemies will try to determine the location of their braintapes before going after them. And if a government sentences someone to death or prison, they will be sure to try to track down all of his braintapes, so that his friends or followers don't revive him.

One problem with braintaping is that it diminishes the fear of death. Braintaping works best as a plot device and "last resort" means of saving people . . . and – at $25,000 per update – a good way of using up characters' funds. The GM should discourage players with braintaped characters from casually committing suicide rather than facing tricky situations such as being imprisoned. One way is to point out that the people back home may not know he's dead, and so may never revive him.

Of course, instructions could be left to have a copy made after the PC has been missing for several years, but his enemies or an accident might destroy the tapes before he can be revived. Even worse, the original may not be dead at all! A PC might return after being shipwrecked on a low-tech planet for five years, only to find that his instructions have been followed and he has been presumed dead and a copy made – and his new self has spent all his fortune, married or even blackened his good name.

Memory Integration Device (TL10)

This device is used to perform memory integration (p. 122). It resembles a double diagnostic bed with oversized neural helmets that cover the entire head of both users. A memory integration device weighs 500 lbs., takes up 50 cf and costs $800,000. It normally runs on building power, but a D cell will operate it for three memory integrations (24 hours).

Portable Braintaper (TL10)

This is a digital braintape recording system small enough to be carried aboard a vehicle or installed in a doctor's office. This sort of system is easier to manufacture than a full braintape machine, so it may be the only type that is available to illegal "black clinics," revolutionary groups or the like. It is basically half a braintape machine, without the extensive safety interlocks and monitoring facilities of its larger cousin. It can only *record* braintapes – it can't play them into a clone's mind, nor can it directly program a clone.

It takes half an hour to read someone's memory into the device, and requires a skill roll against Electronics Operation (Medical). Failure means that another try is required; critical failure means that the scanning has disrupted brain patterns, causing possible brain damage such as Amnesia, Epilepsy or a loss of IQ. If successful, the device stores the person's braintape in 100 gigs of memory on a standard mini-disk. At TL11+, a disk could hold multiple sets of memories in separate files!

At TL10, a portable braintaper weighs 200 lbs., takes up 10 cf and costs $110,000. It uses a D cell, good for a year or so. Weight, volume and cost are halved at TL11 and again at TL12; a TL12+ device fits easily into a small suitcase. A *low-res* portable braintaper (which can *only* make low-res braintapes – see p. 117) is half the normal price.

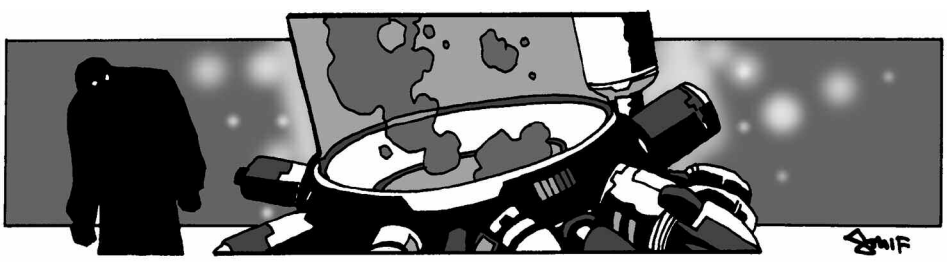
Portable braintapers are rarely available except to licensed physicians, and may be illegal. There are too many sinister things a criminal or enemy agent can do with such a device, such as stealing a copy of someone else's mind. However, this doesn't stop people from making them illegally, buying them on the black market, et cetera.

Portable Programmer (TL10)

This system is used to program a clone directly with a person's mind, or to update a clone using a braintape. To function, the braintape disk must be inserted into the programmer and hooked up to a growth tank (p. 18), forced-growth tank (p. 19) or portable clone tank (p. UT96) containing a clone. At TL10, portable programmers are usually only available to licensed physicians (and government agencies), but by TL11+, even family doctors may have one next to the automedic – politicians often prefer to control the taping machinery while leaving the programmer legal.

Performing either programming or a clone update takes 6 hours and a successful roll against Electronics Operation (Medical). Success means that the braintape was properly transferred. Failure means it was accidentally erased (hope someone has a backup copy . . .). Critical failure indicates it *seemed* to work. At least, most of the memories were transferred. Hopefully. Or if multiple braintapes were on the same disk, maybe they transferred the *wrong one.*

A portable programmer weighs 300 lbs., takes up 15 cf and costs $200,000. This is halved at TL11 and again at TL12+. It uses a D cell, good for a year or so.

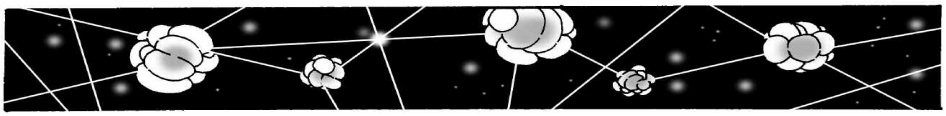


Portable Braintape Machine (TL10)

This combines braintaper and programmer devices. It can be used for either function. It weighs 400 lbs., takes up 20 cf and costs $300,000. This is halved at TL11 and again at TL12+. It uses a D cell, good for a year or so. The same legal controls that apply to braintapers apply to it.

Braincorder (TL14)

An espionage device that can make digital braintapes at a *distance.* See p. UT96.



Braintaping-Related Technology

These are spin-offs of braintaping technology, or alternative versions of it.

Brain Editor (TL10)

Brain-editing software allows someone to use a computer to read, delete or alter memories that are stored on a digital braintape. The braintape is *not* aware of this process (as a ghostcomp would be; see p. 122) – only the data on the tape are being accessed.

Using a brain editor is like using the telepathic Mindwipe skill (p. B171), with a few exceptions. The user is "in contact" with the braintape once he begins to edit it, and Psychology or Brain Hacking (p. CI160) skill is used instead of Mindwipe. The user may search for and "read" specific memories or sets of memories (takes one hour per attempt); if trying to remove or change single memories, or specific areas of memory, he must first locate them. A failed roll does not alert the subject, since the braintape is not conscious. However, if any editing (as opposed to simply searching) was done, it will leave traces that the subject will be aware of if the braintape is actually run – these may be a feeling that something is missing, a memory he knows he should recall but can't, et cetera.

The GM should secretly make *all* rolls for brain editing. The effects of a brain-editing job will only come to pass if that braintape is actually used (in a clone or ghostcomp).

To detect brain editing, use the *Detecting Mindwipe* rules (p. B171) – "the first time you contact" means the first time you access the braintape. Ignore references to Telereceive – if the user has reason to believe brain editing has taken place, he can keep looking (roll each hour); if he doesn't, he gets the initial roll only.

Whether or not brain-editing technology exists is optional. In fact, if it does, it may be secret; if it is known to exist, people may be *very* nervous about who they store their braintapes with! A brain editor program is Complexity 6, $20,000.

Personality Implants (TL11)

These devices are cybernetic implants that allow a braintape to take over a person's mind. They are described on p. UT110.

Personality Overwrite Machine (TL11)

This is a refined form of mental-programming machine, developed from a braintape programmer. It allows someone to "overlay" a personality on top of an existing mind. The result is similar to the personality implants described in ***GURPS Cyberpunk*** and ***Ultra-Tech,*** but instead of the new personality being maintained by an implanted (and removable) device, it produces a permanent change, imprinted onto the subject's brain.

Memory Uploads to Gengineered Clones (TL9)

Here's another way to get a radically different body. A clone is made of the subject (p. 14), but intended genetic modifications are engineered into its DNA. As it matures within its tank, the clone is kept comatose to keep it from developing a mind of its own. When it reaches maturity – or before, if desired – a braintape (see *Braintaping,* p. 116) of the subject is "played back" into the clone. The result is a clone of the user, with his memories but a genemod body.

There are now two versions of the subject. If duplication is undesirable or illegal, the subject could arrange for his original brain to be destroyed or memory-wiped after the transfer process. Then only one copy of him would wake up. Perhaps less wastefully, the original could be kept comatose or in suspended animation, in case it is ever needed as a backup. This brings up the main disadvantage of "clone jumping" for those who want augmentation: Is the braintaped copy really you?

Copy-Protection Nano (TL10)

Not everyone *wants* to be copied! This technology is used to protect a personality from being copied via braintaping technology. It "encrypts" the user's memory and personality using decoy nanomachines, which interfere with braintaping while not affecting the user's brain function in any way. They impose a penalty equal to (their TL-5) on any roll to make a braintape of the user. If no roll for braintaping is normally required, a roll vs. Electronics Operation (Medical) must be made, with that penalty.

A roll that fails by 1 results in a copy that is seriously "defective" – drop quality by one level: normal becomes low-res, low-res becomes very low-res and very low-res tapes are completely useless. A failure by 2 or more means a fatally flawed copy was made; if programmed into in a clone or ghostcomp, the result will be mindless. There is no way to tell whether the copy failed or not without actually using it in the clone or ghostcomp; the GM rolls secretly.

If soul collectors exist, the GM should decide whether or not they can be jammed; if so, roll 3d vs. the nano's TL. On a success, the nano prevents the soul collector from working.

Continued on next page . . .

Copy-Protection Nano (TL10) (Continued)

Copy-protection nano can be inhaled or injected. It begins to protect against copying within 1d×5 minutes.The nano may be built with a limited lifespan (set by the designer), or may be permanent symbiotes. A dose of copy-protection nano costs $10,000. There is no character point cost.

Memory Integration (TL10)

In some societies, cloning and braintaping technology may allow multiple clones of the same individual to exist, sharing similar memories. However, under normal circumstances, they rapidly become different people as a result of their own, unique experiences. In certain instances – for instance, after a secret agency sent multiple duplicates of the same super-agent on different missions – it may be desirable to integrate the experiences of several braintaped clones back into a whole.

A memory integration device (p. 120) allows a person and an identical clone (or two identical clones, if neither is the original) to do just that. Both subjects must be present and hooked up to the device, which uses a mix of chemical RNA transfer, electrosynaptic brainmapping and braintaping to identify, transfer and integrate their differing memories. The process takes 8 hours, during which both copies are unconscious. When it is over, both share the same set of memories.

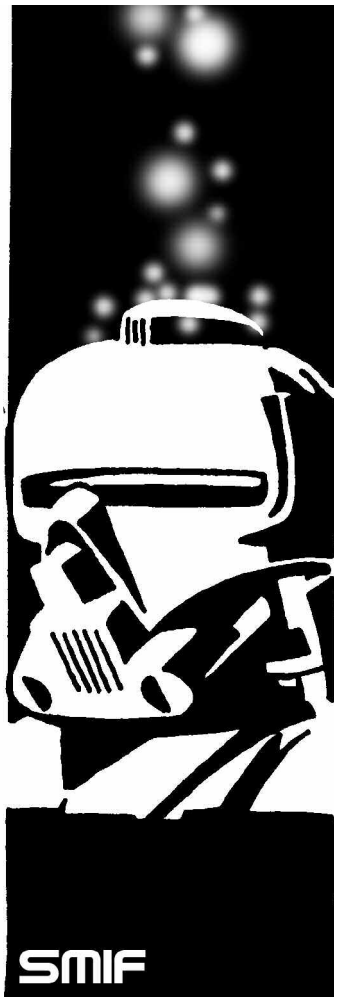
The memory integration process also acts as a form of "quick teaching." Skills are partly transferred. If one clone has more character points than the other in a specific skill, half the difference is transferred if it is a mental skill, or one-quarter the difference if it is a physical skill. Round fractional skill points below 1/2 point down. Unfortunately, newly-gained mental disadvantages (e.g., from failed Fright Checks or other causes) are also transferred!

Recovery from the memory integration process can take some time. The process stirs up a lot of old memories and images (even ones shared by both clones). Each user will suffer from the Flashbacks disadvantage for at least 1d weeks afterward.

Continued on next page . . .

A personality overwrite machine weighs 300 lbs., takes up 15 cf and costs $300,000. This is halved at TL12 and again at TL13+. It uses a D cell, good for a year or so.

Uploading: Ghostcomps (TL14)



A digital braintape can be installed in a specialized computer, known as a *ghostcomp* (p. UT31). The personality (or "ghost") then becomes fully self-aware. It can think (as long as the computer is on), remember things, learn, and communicate with others through the computer.

All ghostcomps are designed to allow the braintape to access the computer's databases and to run its programs. The capabilities of the ghost personality depend on what hardware and software are available to the computer. Through a datalink or modem, a braintape could reach out to other computers, control a vehicle or spaceship, or project a realistic image of his old body using a linked holographic projector. By datalinking with a chrysalis machine (p. 23) or growth tank facility, he could even start growing a body!

Some ghostcomps are designed with a safety override, which can lock out some or all databases and programs; thus, it is possible to keep a braintaped personality "imprisoned" or controlled. Kidnappers might even "steal" the mind of a famous scientist or skilled politician or strategist. Then, by offering limited access or promising eventual freedom, such a "bound ghost" could be made to work for his captors. A person can escape that kind of digital imprisonment simply by having someone hack into the computer, copy the braintape file, then delete any copies on the machine. Of course, they may have backups . . .

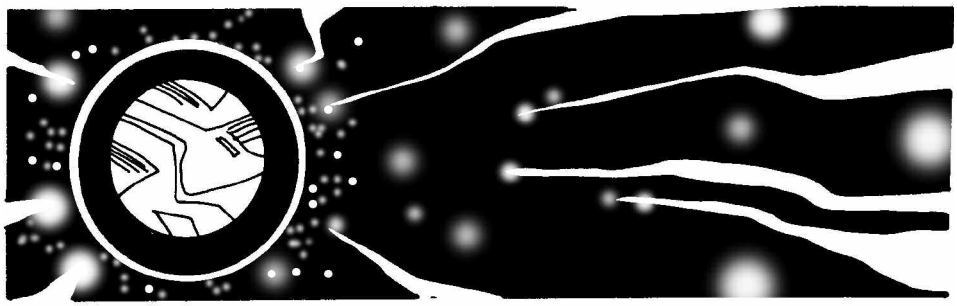
A ghostcomp is identical to any Complexity 8+ computer, except that it costs 10 times as much; this includes making the computer a neural-net type design. By default, ghostcomps are TL14, with the braintape program being Complexity 8. However, it's quite possible that ghostcomp technology may be no more difficult than regular braintaping. If so, GMs may wish to make ghostcomp technology only Complexity 6 and/or TL10. LC 4.

If ghostcomps are widespread, an entire community of recorded personalities may exist. In a sense, they could be "mobile," surfing the net and manifesting as holograms, or within dreamgames or virtual reality simulations.

Global Soul Collectors (TL15)

What if science discovers that memory and personality also exist as an energy form independent of (but perhaps created by) brain chemistry, which can (at least briefly) survive the death of the body? If so, it may be possible to create a machine that will snatch this "energy soul" as it escapes and transfer it to a new body, permitting resurrection! This is definitely "psionic technology," and more fantasy than science fiction, but devices of this sort have appeared in several SF novels, notably Philip Jose Farmer's *Riverworld* series, Tanith Lee's *Don't Bite the Sun* and Roger Zelazny's *Creatures of Light and Darkness.* Here's how they might work:

The *global soul collector* is an area-effect device that can collect energy souls as they leave bodies after death and store them in some kind of matrix. Depending on the size of the soul collector, it can snatch energy souls throughout a building,



city or planet-sized region. A soul collector is usually designed to gather only the energy souls of intelligent beings, either because non-sentients lack souls, or simply to prevent it being from becoming overloaded.

The physical requirements of a global soul collector are really up to the GM. Here are some suggestions:

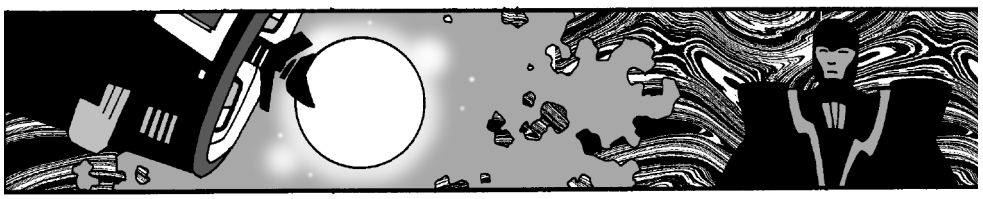
Size	Radius	Weight	Cost	Power
Building	7 yds.	1 ton	$1 bil.	1 MW (Megawatt)
Block	70 yds.	3 tons	$3 bil.	3 MW
Neighborhood	0.5 mi.	10 tons	$10 bil.	10 MW
City	5 mi.	30 tons	$30 bil.	30 MW
County	50 mi.	100 tons	$100 bil.	100 MW
Regional	500 mi.	300 tons	$300 bil.	300 MW
Continental	5,000 mi.	1,000 tons	$1 tril.	1 GW (Gigawatt)
Planetary	50,000 mi.	3,000 tons	$3 tril.	3 GW
Solar System	50 AU	1 mil. tons	$1 quad.	1 TW (Terawatt)

At the GM's option, larger-area models may also be possible, although it would seem more practical to build a soul collector for each planet or system. The GM can assume that a soul collector can reach "through" any solid object to gather soul energy. Optionally, force screens or more specialized energy fields may prevent soul collection. If two soul collectors are operating in the same area, the soul is drawn to the nearest one.

A collector must be supported by a computer system (at least Complexity 10) with 100 gigs of storage space for each soul that it can store. If there is no room left, the soul collector will not function until storage space is freed by transferring out souls. Where soul collectors are designed as resurrection machines, they are usually built so as to be capable of holding a sizable percentage (or even *all*) of the population in the area they cover, to ensure that a major disaster does not overwhelm their storage capacity.

Energy souls can be transferred to blank-minded bodies (usually clones of the original, but transfer to other blank-minded bodies is possible). Use the rules for programming clones, treating the energy soul exactly as if it were a TL10+ braintape. Soul collector installations are normally equipped with clone tanks and hospital facilities of some sort to facilitate such transfers.

The theological implications of the global soul collector are unsettling: it might prevent people from ascending to an afterlife, or "heaven" or "hell" might simply be an organization with one of these devices. Certainly, a group or individual who controlled one would possess godlike capabilities.



Memory Integration (TL10) (Continued)

During this time, the user will experience flashbacks of both his own older memories and, especially, any memories that the other clone had that he did not previously have. After 1d weeks, the user gets an IQ-2 roll each week to shake off the flashbacks.

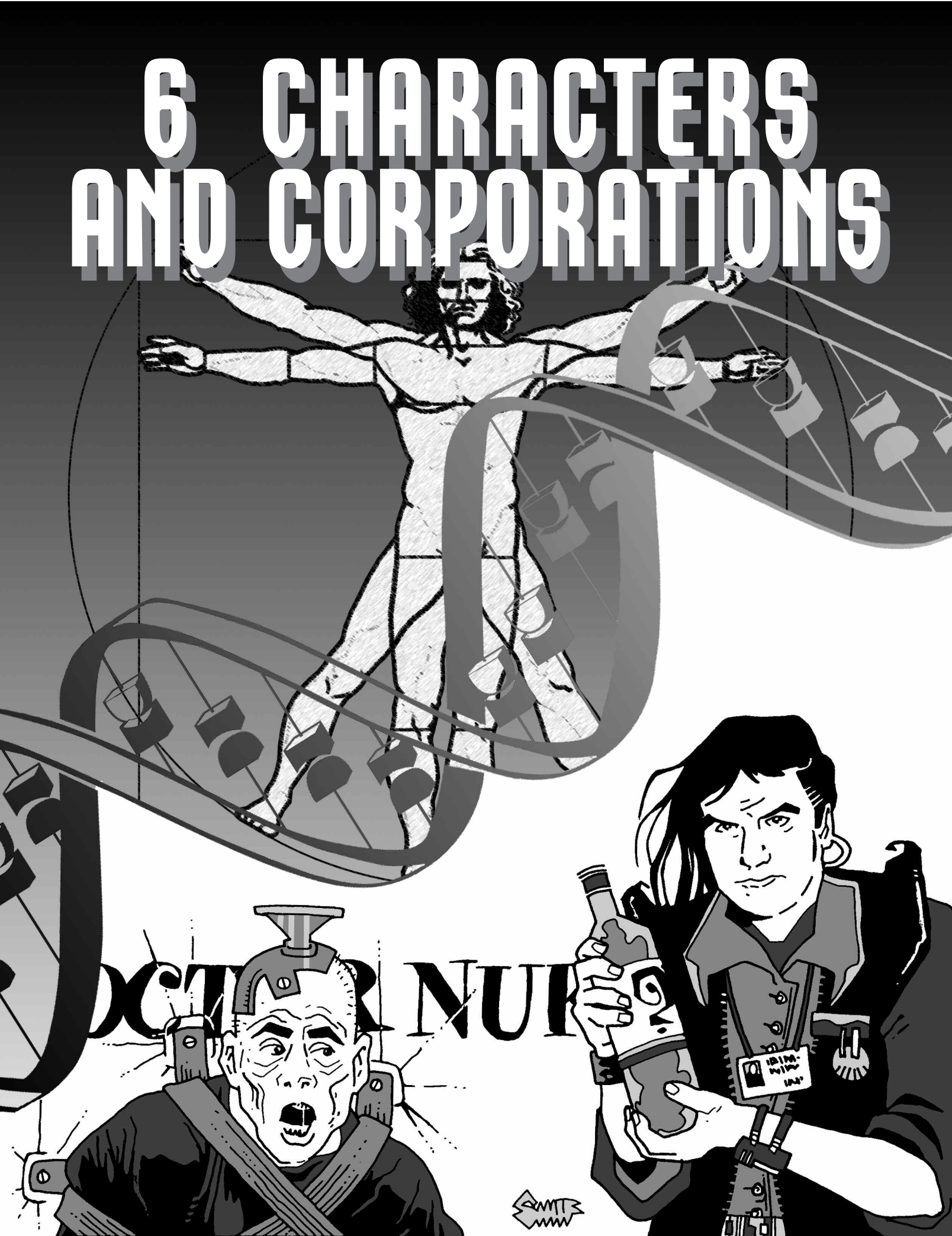
Memory integration requires Electronics Operation (Medical) skill to perform, and the process must be monitored by a human or a computer. Roll separately for each person being integrated. A success indicates that the transfer process went off without a hitch, with the effects described above. A failed roll indicates that memory integration was only partially successful. Everything seems right, but the memories (and any newly-gained character points) will only last for as long as the flashbacks do.

A critical failure indicates that the wash of new memories and the stirring up of old ones caused a mental imbalance, resulting in the character gaining a new disadvantage. For instance, if the two users had very different experiences, one may develop a Split Personality rather than integrating the two sets of memories. Alternatively, a person may remember traumatic incidents from earlier in his life with new clarity, resulting in a Phobia or other mental disadvantage. Yet another option is that the simple psychic stress brought upon by the flashbacks results in a disadvantage such as Bad Temper or Manic-Depressive.

Memory integration cannot be safely performed again until the new memories have been fully integrated (i.e., the flashbacks end). If it is so used before then, any success except a critical success is treated as a failure, and any failure becomes a critical failure.

Use of memory integration may cost character points, at the GM's option. The suggested point cost is equal to the character point value of any skills that were gained through the process, minus the cost of any new disadvantages gained. The GM can either require the character to set aside a fraction of his earned points to pay for these skills at a later date, or simply raise the point value of the character. Availability of memory integration is sometimes restricted due to its potential for psychological damage. If multiple braintaping is legal, it's LC 4. In societies that prohibit multiple braintaping, it will be LC 0. If available, a treatment will cost $4,000 per personality being integrated.

6 CHARACTERS AND CORPORATIONS



"Mad? I, who have discovered the secret of life! You call me mad?"
– The Vampire Bat (1933)

To the average person, future biotech may be essentially invisible. Panimmunity shots he had as a baby keep him healthy. He pours milk from transgenic cows onto his cereal made from nitrogen-fixed grain, and complains about how much of his salary goes toward health care plans that will keep him alive for an ever-increasing span. Perhaps his parents even had him genefixed, to remove any genetic defects. But biotechnology won't be invisible to everyone – there will be some people for whom biotech may be a business, a way of life or even a crusade.

Biotech Characters

Character Types

These archetypes are typical of people intimately involved in biotech and gengineering.

Bioengineer or Gengineer

"Don't you see? My discovery will change the world!"

A scientist or engineer working in a field such as gengineering or industrial biotech. Some bioengineers are employed by corporations, while others work in university labs or even as freelance "genehackers." A bioengineer may be anything from a simple lab technician to a Nobel-prize winning researcher.

A common genre convention is the idealistic scientist who develops a process to benefit mankind, only to see it stolen and perverted by a rival or treacherous co-worker who is in the pay of a big megacorporation's bioweapons division. Another is the obsessed genius whose cutting-edge project was so controversial that he was fired from his job or driven out of the field. Now he lives alone somewhere and continues his ground-breaking work in private, often without adequate biohazard safeguards.

Common Advantages: Academic Status, Contacts, Eidetic Memory, Tenure or Wealth (if established). For geniuses, Intuition and Versatile, and in cinematic campaigns, Gadgeteer.

Common Disadvantages: Absent-Mindedness, Obsession, Overweight, Poverty (if grad student), Shyness, Skinny.

Useful Skills: Biochemistry, Computer Operation, Electronics Operation (Medical), Engineering (Biomedical), Genetics (Genetic Engineering), Psychology, Research, Xenobiology and possibly other scientific skills. In cinematic campaigns, Science! and Weird Science.

Biotech Executive

"I'm afraid we cannot permit you to continue that research, doctor. The way public opinion has swung, such work on human germ cells would be detrimental to Metazyne's corporate image."

Biotech and Cyberpunk

Truth: A lot more cyberpunk fiction leans toward the biological end of the spectrum than leans toward cybernetics. It's only because of all the netrunning that we call it "cyberpunk" and not "biopunk."

At this point, we should probably warn ***GURPS Cyberpunk*** GMs to exercise caution and avoid disrupting the campaign with all kinds of new, campaign-destroying technology. On the other hand, future shock is a major theme in cyberpunk fiction! Just make sure it's part of the story. For instance, a new biotech company announces a dramatic breakthrough, things begin leaking onto the streets, and other corporations follow suit. Massive economic disruption results, with protests in the street, fanatics burning themselves to protest the desecration of the human genome and all that.

It's up to the GM to decide how pervasive biotech really is. It can be new and hard to get, or just as common as cybernetics. A cyberpunk world can even be *mostly* biotech, with chrome and silicon being rare and unusual.

Another interesting way to handle biotech is to have one organization, nation or culture specialize in cybernetics and another in biotech. Bruce Sterling's *Shaper/Mechanist* stories (see *Bibliography,* p. 141) are a good example of this kind of cultural divide. If the GM wants to keep biotech under control, the most advanced biotechnology could be limited to an outlaw group or culture.

Using *GURPS Bio-Tech* with *Cyberworld*

As written, ***GURPS Cyberworld*** is pretty mum about biotech, except for some references to human cloning not yet being possible, nanomachines being used for cybernetics and some weird biocomputers bubbling away in a few korp labs. Biomods? Human gengineering? Pharming? Not mentioned in the book.

The easy answer is to assume that biotech *isn't* on the streets – although it may exist in korporate "black projects" somewhere. On the other hand, why be a stick in the mud? Remember, that was in 2043! If the future keeps pace with the present, the "new now" is nearly five years later, and in the future-shock world of the One-and-Twenty, five years is more like five decades. Maybe they've got it *now*.

Even so, the GM may want to limit ***Cyberworld*** biotech to TL8-9 – muscle grafts and implant glands are state of the art but available, while things like bio-nanotech transformations and genetic super-soldiers are still a biokorp scientist's wet dreams.

Cloning in *GURPS Cyberworld*

Cyberworld indicates that human cloning is not yet possible (p. CW106). "Real world" events have overtaken this. GMs may wish to modify this to "human cloning is possible, but no human clones have been brought to term." More logically, GMs can assume that human cloning has been performed, but is illegal in many or most nations, and that forced-growth tanks (p. 19) that allow rapid raising of clones to adulthood do not exist. With a clone taking 18 years rather than 6 weeks to mature, this limits the social impact of cloning in the One-and-Twenty.

A senior manager in a bioengineering company. Small, dynamic companies are often helmed by former or current scientists, until they make it big and get bought out by or turn into huge conglomerates. Often, the new management are businessmen, pure and simple, which can lead to conflict between the scientists (who enjoy pure research projects) and the executives (who'd rather see a profit in the next fiscal year or two).

It can be fun to play the head of a small, struggling company, especially if the competition is doing everything – up to and including biological warfare – to wipe you out. The biotech exec also makes a good villain: He's the guy who orders the ruthless cover-ups when something controversial or dangerous escapes from the lab, or who arranges expeditions to alien worlds to find deadly new species for the Bioweapons Division.

Common Advantages: Ally Group, Charisma, Multimillionaire, Patron, Security Clearance, Status, Strong Will, Wealth.

Common Disadvantages: Bully, Duty, Enemy, Greed, Jealousy, Obsession, Workaholic.

Useful Skills: Accounting, Administration, Computer Operation, Detect Lies, Diplomacy, Economics, Fast-Talk, Intimidation, Law, Leadership, Merchant, Politics, Writing.

Bioterrorist

"Listen up, pigs! Unless you free ALL the political prisoners in three hours, the Neo-Anarchist Kommando will release a bio-engineered strain of hantavirus in New York City."

A terrorist or extortionist with a biological weapon. Most terrorists are extremist fanatics, but they can range from lone madmen with a grudge to highly-organized movements with dozens of members and thousands of supporters. Terrorists can also represent the extremist element in causes that have some degree of popular sympathy, such as environmental activism, or support for the rights of gene-altered individuals.

A terrorist bioweapon doesn't have to be a lethal plague: nonlethal diseases, nanomachines, proteus viruses, insect swarms and mutant monsters are all possible. Often, these are cooked up in bargain-basement labs, or acquired through theft or on the black market. As a result, they might be more or less virulent than the terrorist hoped for, or have other unexpected side effects.

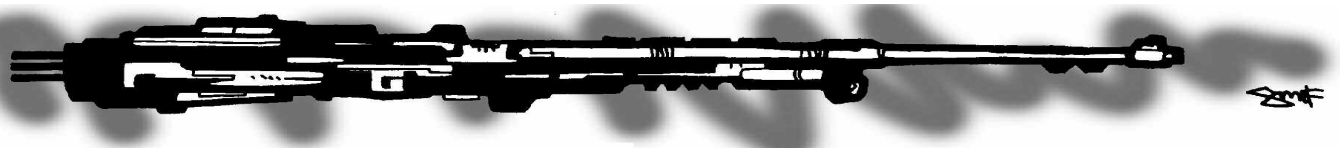
Common Advantages: Alertness, Ally, Ally Group, Alternate Identity, Contacts, Danger Sense, Patron, Zeroed.

Common Disadvantages: Bloodlust, Enemy, Extreme Fanaticism, Fanaticism, Intolerance, On the Edge, Reputation, Stubbornness, Trademark.

Useful Skills: Acting, Armoury, Bard, Chemistry, Computer Hacking, Demolition, Forgery, Genetics (Genetic Engineering), Guns, Holdout, Intimidation, Leadership, Stealth, Streetwise.

Ecological Engineer and Ecoteur

"A planetary ecosystem is a complex entity, a synergistic whole. Even seemingly-insignificant changes have the potential to send shock waves that ripple across the entire biosphere."



Ecological engineers are specialists at redesigning regional or planetary ecosystems for the purposes of terraforming. They also work to correct the depredations of environmental disasters such as pollution, overpopulation, failed terraforming experiments and deliberate sabotage by ecoteurs. They combine a knowledge of genetic engineering with an understanding of how even minor changes can effect entire planetary ecosystems.

Ecoteurs are the dark side of the ecological engineer – sometimes even former eco-engineers "gone bad." These are mercenary, corporate or government agents who specialize in ecological sabotage ("ecotage") aimed at disrupting or destroying the relationships between species. Ecotage is typically aimed at destroying a competitor's economically-valuable crops or livestock, but it might also be intended to force the current occupants of a sabotaged region to leave or surrender.

Some ecotage activities may be very straightforward. For instance, a "rabbits in Australia" ploy of introducing a dynamic new species into an ecosystem that isn't prepared for it in order to displace existing species, or simply to kill livestock, crops or people. Ecotage can also be very subtle. For instance, an ecoteur who has been hired to disrupt a region's economy might release a bacteria that kills birds that prey upon a species of insect, resulting in the insects multiplying rapidly and devouring an economically-important crop. This sort of ecological sabotage can be very hard to quickly trace back to the source, and in some cases, an enemy is not even aware that sabotage has taken place!

Advantages, Disadvantages and Skills: Similar to those listed under *Bioengineer* (p. 125) for eco-engineers, or to those listed under *Bioterrorist* (p. 126) for ecoteurs. In addition, Ecology, Economics and Planetology are must-haves.

Gene Cop

"This is the Genetic Regulatory Agency! This lab is sealed! I am placing you under arrest under Article Two of the Human Genetic Standards Act, for unlawful violations of the human genome."

A member of an agency that enforces laws regulating genetic engineering or other types of biotechnology. Depending on the perceived threat, gene cops may spend most of their time on routine inspections of commercial and university labs, or they might lead undercover investigations or SWAT-style assaults on black market clinics, organleggers and illegal genetics labs.

A variation of this is the "exterminator" or "bounty hunter" character, whose job is to hunt down people or animals that have been illegally gengineered, or bioroid slaves or experiments that have escaped or gotten out of control. Gene cops of this sort may be mercenaries or freelance bounty hunters.

Common Advantages: Alertness, Combat Reflexes, Contacts, Intuition, Legal Enforcement Powers, Patron, Unfazeable.

Common Disadvantages: Bully, Duty, Honesty, Intolerance (illegal genemods), Overconfidence.

Useful Skills: Beam Weapons, Computer Hacking, Computer Operation, Criminology, Detect Lies, Diagnosis, Electronics Operation (Medical), Electronics Operation (Security), Forensics, Guns, Holdout, Intelligence Analysis, Interrogation, Intimidation, Law, NBC Warfare, Psychology, Shadowing, Stealth, Streetwise.

Experimental Procedures

Biotech *may* be available at an earlier TL than listed, as an "experimental procedure." This includes early human trials of specific biomod processes, experimental gengineering projects, and so on. In general, an experimental process will cost at least 10 times as much if half a TL early; e.g., a TL8 procedure at late TL7, or a late-TL7 procedure earlier in TL7. At the GM's option, some developments could be available a *full* TL early, at 100 times cost or more!

There's a fair chance that any such newly-invented process will have bugs in it – the GM can apply cross-tech penalties to skill rolls (p. B185) for surgery or gengineering tasks, or simply assign additional side effects (usually disadvantages) to anyone or anything that has undergone it or been created by it.

Post-Human Clothing

Visit Jeremy Fogg's Vacshop on Ceres for all your custom needs. We'll convert the gloves, sleeves, pant legs and boots of all your clothing, armor and spacesuits to fit your prehensile feet, tails, tentacles or whatever! See our new line of toe-gloves, tail sacks and flexisleeves! Jeremy Fogg: Meeting the needs of post-human morphs everywhere.

Full-body suits, armor and clothing for people who require extra sleeves, legs or "tail socks" are +10% to weight and cost per extra limb. There is no extra cost or weight if the extra arm, leg or tail is outside it (e.g., a tail sticking through a flap) –this only applies if the suit must cover it.

Cleanup

NBC Warfare skill (p. 134) includes knowledge of cleaning up biologically-contaminated areas. Good tools are decontamination aerosol (p. UT79), viral solvent (p. UT84) and nanocleanser (p. UTT30). Labs (p. 21) may be equipped with ultraviolet lamps that can kill germs. Ordinary disinfectants may work in some cases. The top-of-the-line method is disassembler nanomachines (p. UTT69) programmed to destroy a particular germ and nothing else. If all else fails, fire (or nuclear weapons) can be used . . .

Genemod Human

"In the past, one people would oppress or enslave another, especially other ethnic groups, and justify this with lies about racial superiority or inferiority. In reality, the differences were essentially cosmetic and environmental. Well, we enhanced humans are a minority, but we ***are*** *different. Truly different. We have to take this into account whenever we deal with mundanes. They won't let us forget it. Neither should we."*

Someone who was grown from gengineered germ cells, or who has been cloned or biomodified. Depending on society's views and the extent of his modifications, people may consider him superhuman, a member of a privileged class, perfectly normal, unusual, a freak or even a non-person or outlaw.

If he was born with his modifications, he may not think of himself as special, but if the majority of the population is unaltered, the simple awareness of difference – even apart from the changes themselves – may make a significant impact on his life.

Advantages and Disadvantages: A variant-human racial template. Anything else is possible, as long as it doesn't violate any taboo traits in his template. Social Stigma and Unnatural Features are quite likely.

Hazmat Specialist

"Seven ebola-infected, genemod alligators escaped into the sewers? Yep, you called the right people. Have the authorities been informed? Ah, I see. Well, that's extra. Don't worry. We've handled these things before. We'll send our best team."

An expert at cleaning up hazardous materials, vat spills and other biochemical disasters. Such experts may work for a fire department, disease-control center, genetic regulatory agency, police force, military unit or corporation, or be free-lancers hired to clean up others' messes. Biohazard specialists may also be trained to deal with hazards such as killing lab animals infected with diseases or exotic horrors escaped from a military lab. A hazmat team may include bioengineers or eco-engineers capable of whipping up specialized bacteria or counter-bioweapons to deal with a problem.

Common Advantages: Combat Reflexes, Disease-Resistant, Fearlessness, Immunity to Disease, Resistant to Poison.

Common Disadvantages: Extremely Hazardous Duty, Nightmares, Sterile, Terminally Ill.

Useful Skills: Animal Handling, Beam Weapons (Flamer), Biochemistry, Demolition, Diagnosis, Driving, Electronics Operation (Sensors), Guns (Flamethrower), Guns (Tangler), NBC Warfare, Net, Physician, Poisons, Tracking, Traps and possibly other combat skills.

Neo-Luddite

"Storm the lab complex! Destroy the abominations within!"

An activist who opposes some or all types of gengineering on social, ethical or religious grounds. Neo-Luddites range from peaceful lobbyists or picketers to violent extremists. They may be associated with or recruited from "left wing" groups, like animal rights activists and eco-guerillas, or from "right wing" groups, like conservative religious movements. Violent neo-Luddites may turn to bioterrorism, either to "fight fire with fire" or to attempt to discredit their foes. The ***Kung Fu 2100*** setting (see ***GURPS Martial Arts Adventures***) has kung fu neo-Luddites fighting the sinister Clone Masters!

Common Advantages: Ally Group, Charisma, Clerical Investment, Strong Will, Voice.

Common Disadvantages: Fanaticism, Gullibility, Intolerance (genemod people), No Sense of Humor, Sense of Duty (humanity), Stubbornness, Technophobia.

Useful Skills: Bard, Brawling, Computer Hacking, Demolition, Ecology, Fast-Talk, Intimidation, Law, Lockpicking, NBC Warfare, Philosophy, Stealth, Theology, Video Production.

Organlegger

"19 years old, good heart and lungs, healthy kidneys, no diseases . . . a jogger, huh? Good choice, Charlie. Problem with snatching street people, they've got so many retroviruses and defects, it's not worth the trouble these days. Now this is prime stuff: at least $200,000. Break her up, and burn the brain."

Organleggers (a term coined by Larry Niven) kidnap people and break them down for spare parts or – more subtly – loot the organs of sick or dying patients during hospital visits.

As the populace ages and immunosuppressant drugs improve, the correct types of organs sell for huge profits on the black market, to people desperate for transplants. The demand may slacken after bionic or cloned organs become available at TL8-9, but organleggers can still turn a profit by offering their wares at lower prices. At TL9+, a potential market for adult human brains to be enslaved inside cyborg spaceships, biocomputers or factories could keep organleggers busy.

Common Advantages: Alertness, Alternate Identity, Danger Sense, Wealth.

Common Disadvantages: Callous, Enemy (law enforcement), Greed, Low Empathy, Solipsist.

Useful Skills: Beam Weapons, Diagnosis, Electronics Operation (Medical), First Aid, Forgery, Guns, Holdout, Merchant, Physician, Streetwise, Surgery.

Senior Citizen

"Well son, I'm 97, and most of the last 15 years have been spent in hospitals like this one. Now you're telling me that if I let you pump that million dollars worth of nano-gook through my body, there's an even chance it'll either make me fifteen again or kill me. Gotcha, son. Where's that consent form?"

The desire of elderly people to escape death may be the driving force behind radical advances in human biotechnology. The aged will actively follow the latest life-extension treatments (and vote more money for health care subsidies, if these exist). The extremely rich can afford to sponsor competing lines of cutting-edge research, ranging from anti-agathic drugs and brain or organ transplants to cryonics, nanotechnology and braintaping. When it is a question of trying out these treatments or dying, they may well be the guinea pigs for experimental therapy.

Sometimes even illegal therapy . . .

Common Advantages: Allies (younger relatives), Common Sense, Contacts, Multimillionaire, Reputation, Wealthy.

Common Disadvantages: Absent-Mindedness, Age, Bad Sight, Disembodied Brain, Enemy (including younger relatives!), Extra Sleep, Hard of Hearing, Hidebound, Obdurate, Poverty (spent it all on health care), Short Attention Span, Stubbornness, Terminally Ill, Unattractive, Weak Immune System.

Useful Skills: High levels in former job skills. Research (for diligent study of cutting-edge health care and life extension plans).

Splicer

"Welcome to the Clinic Rouge, monsieur. Our discretion is assured."

Outlaw medics. Street docs. Genehackers. These "splicers" range from unlicensed or defrocked physicians to the staff of ultra-tech "black clinics" (see p. 135). Many are simply out-of-work or struggling students moonlighting for extra cash.

The Organ Trade

Medical transplants can save or extend lives, replacing lost and damaged organs. Until synthetic or cloned replacements are both available and cheap (which might not happen until late TL8) donated organs, especially hearts, kidneys, livers and lungs, may be in great demand. See *Medical Transplants* (p. 65) for details of the transplant procedure.

In most places, organs and other tissues can be legally taken from a recently-deceased person only if he agreed to be a donor beforehand (often indicated by a donor card), or if his relatives make the decision. For personal or religious reasons, many people are unwilling to make that decision. Others die in circumstances (old age, disease, major trauma) where their organs are damaged or unhealthy. A supply of suitable organ transplants requires finding people who died in good health. As this is almost a contradiction in terms, locating organ donors can be difficult.

At present, the number of altruistic people who die healthy is insufficient to meet the demand for new organs. This will probably get worse as transplants become more common around the world. (It may get a *lot* worse if cryonics becomes popular, since if you hope to be frozen after you die, you may need those organs later!) While this demand may be mitigated if bionic organs become cheaper and smaller, it may not go away entirely.

Because of this demand, hospitals often have to put needy patients on month- or year-long waiting lists for high-demand tissues, such as the body's vital organs or eyes. The GM can decide how long a wait is necessary, or roll randomly. Before cloning is widespread (reducing the demand), a 1-in-6 chance of matching major organs being available might be typical, with a further chance rolled each month. After cloning, artificial organs or bionic replacements become common – a 1-in-6 chance per *week* is more likely. Things like fingers or limbs will be in less demand, and may be available without a wait in most cases.

Scarce transplants can also mean a black or gray market trade in organs and other body parts.

Black Market Organ Prices

Typical Costs: $10,000 for a healthy vital organ (heart, lung, kidney). Arms and legs are half that price, since there usually isn't as much demand for them. Eyes, genitalia and other secondary bits are about $2,500 each, with tertiary bits like fingers or ears going for about $500-$1,000. A recently-dead corpse, in good shape (no diseases, not riddled with bullets, et cetera), may sell for anywhere from $10,000 to $30,000 depending on supply and demand, while a live body sells for $50,000.

These prices assume that cloned or bionic parts are widely available. If not (e.g., at TL7), all prices should be doubled or tripled due to increased demand! These are *retail* prices – organleggers, hospitals and so on purchase bodies or body parts for only about 10-60% of this.

Some splicers are as ethical as any licensed physician, while others will do almost anything for money. A few enjoy working in the shadows, for it gives them an opportunity to test cutting-edge procedures on live subjects, or perform experiments that would never be approved by government regulators.

Common Advantages: Alternate Identity, Contacts, Immunity to Disease, Wealth.

Common Disadvantages: Callous, Enemy (law enforcement), Greed.

Useful Skills: Diagnosis, Electronics Operation (Medical), First Aid, Forgery, Genetics (Genetic Engineering), Merchant, Physician, Streetwise, Surgery.

Acquiring Biomods

Biomods (see Chapter 3) that a character starts the game with cost points rather than cash. But what about characters who want to gain biomods in play?

Each biomod's availability (TL, LC and means of acquisition) is summarized in its description. In theory, one simply has to locate someone who can make or install it, pay them, then undergo the operation. This might be as easy as visiting a neighborhood clinic and plunking down a credit card, or as complex as finding an outlawed scientist who's the only one who can perform the operation. Usually, it depends on the TL and LC of the biomod.

And the *point* cost?

The GM may insist that PCs have the requisite character points *before* acquiring new biomods. If a character has an upgrade operation anyway, the GM can hold back future character points until the modification is paid for. However, some biomods are expensive – it's not much fun to stall all development for a year or two while paying off that new hyper-lung. One approach is to require a fraction (e.g., 50%) of earned points go toward paying off the biomod, while the rest are free to use.

Alternatively, the GM may choose *not* to charge character points for biomods under certain circumstances – or at all. The money or effort spent to acquire a biomod, or the risk of the operation itself, might be seen an adequate balancing factor. Extenuating circumstances could also affect this decision. For instance, if all the player characters join the Imperial Marine Corps, which routinely gives its recruits biomods worth 50 character points, then there is less of a game-balance issue – every character has undergone the same procedure, and the GM might as well simply increase each PC's point total by 50 points.

Biomods that are net disadvantages work the same way: They reduce the character's point total, but don't give any new points to spend. If Eden Harrier is a 120-point character when the Dragon Lady of the Yakuza uses a neurovirus to make him Lecherous (-15 points), then he simply becomes a 105-point character.

If a character already has a lower level of the advantage or disadvantage granted by the biomod (e.g., a biomod grants Very Beautiful appearance and the character is already Attractive) the point cost is based on the difference.

Sensa-Skin and Point Costs: A sensa-skin graft is treated as equipment, not an advantage or disadvantage, unless the graft is left on long enough to become a permanent part of the body. Only then should points be charged for it.

Advantages and Disadvantages

This section describes advantages and disadvantages that require special consideration in a biotech-rich campaign setting. For new advantages, enhancements and limitations that apply to biomods, see the *Appendix* (p. 135).

Advantages

Alternate Identity — p. B233, p. CI20

At TL8+, an alternate identity will normally include your genetic pattern as well as finger and retina prints.

Unusual Background: Gengineered — 5 points

You are the living product of germline gengineering (or other genetic modification). If the genetic engineering gives you positive attribute modifiers, or racial or super advantages that an ordinary human cannot take, then the suggested cost is 5 points.

Exceptions: If genetic modification of this sort is *not* unusual in a TL8+ society (GM's option), the cost should be 0. If the genetic engineering is simply a special effect explaining why you haves certain attributes, advantages or disadvantages within the human norm (e.g,. Beautiful appearance, Combat Reflexes or Immunity to Disease), it is also worth no points.

Disadvantages

Hereditary Disadvantages

In a society that practices genetic selection and gene therapy, certain disadvantages are probably very rare at TL8 and nonexistent by TL9.

These include Bad Sight, Bad Smell, Color Blindness, Dyslexia, Hemophilia, Migraine, No Sense of Smell/Taste and Tourette's Syndrome. In addition, Albinism, Dwarfism, Fat and Gigantism are likely to be almost unknown, unless one's parents or creator deliberately wanted such a disadvantage.

A character born into a society like this should justify any such disadvantages in his character story. For example, his family might have been poor, or their religion forbade gengineering, or he could have been subjected to some mutagenic or nano-tech bioweapon, et cetera.

Intolerance — p. B34

Intolerance toward gene-altered people may become a common form of racism. The reverse is also possible, with gene-altered people being prejudiced against unmodified humans.

Reputation — p. B17

"Mass produced" bioroids or clone families may have to live down reputations based on what other examples of their type have done, due to a public perception that they are a puppets to their genes. This is especially likely if they are treated as products or slaves. For example, if it made the news that a Tiger Lily-series pleasure bioroid killed her owner and ran away, all Tiger Lily models may get a reputation as "dangerously unstable," regardless of the events (e.g., that particular bioroid was being abused by her owner, and acted to save her life).

In a society where genetic testing is common, those known or believed to have a genetic defect may also face prejudice, even if they look perfectly normal. This differs from Social Stigma, where the stigma must be obvious to anyone (see p. B27) for it to be worth points.

Secret — p. B238, p. CI78

If a society has laws or prejudices against gengineered people, someone with hidden modifications will have a Secret.

Social Stigma — p. B27

People who are visibly gene-altered – especially those who are very exotic, such as anthropomorphic animals – may suffer a Social Stigma in some societies. If gengineered exotics are uncommon and the unaltered majority is prejudiced against them, they will be classed as *second-class citizens* or a *minority group.* If genemods are illegal, an exotic may be an *outlaw.* An exotic who is the result of an experiment is probably *valuable property.* Even if he's legally a person rather than an animal or slave, people will want to study him, protect him, et cetera.

Of course, in a world where gengineering is the rule rather than the exception, visibly *un*altered people may suffer from a Social Stigma!

Universal Donors

Human genome mapping (p. 14) is an important component of TL8+ organ transplants, as it allows the genetic patterns of donated tissues to be matched precisely with those of recipients.

In some SF backgrounds, rare genotypes may be discovered that make excellent "universal donors." This is the case in the ***GURPS Cyberworld*** setting (p. CW77). Tissue from a "universal donor" has no chance of being rejected.

The fact that a person is a universal donor would be known to his doctor and probably his insurance company. This sort of genetic information is, of course, confidential. On the other hand, genetic records can be illegally stolen, hacked into or otherwise disseminated – and once word gets around that a person is a good source of spare parts, he may be in trouble.

Possible dangers include being kidnapped by organleggers (p. 129) or fetus farmers (see *Fetal Tissue Transplants,* below), or being besieged by desperate people who want to offer lots of money in exchange for a lung or kidney. If cloning exists or is under development, a lab might also want to take (or steal) tissue samples for cloning, in order to make "generic" cloned tissue available to its clients.

Someone who is a universal donor may have a Secret or, if word gets out, a Reputation.

Fetal Tissue Transplants

Fetal tissue is extremely adaptable and capable of very rapid growth. As it's unlikely to be rejected, it makes useful transplant material. Fetal tissue may be acquired from legal abortions or miscarriages. At TL9+, it can also be vat-grown.

At TL8, the demand for fetal tissue may exceed the supply. As a result, illegal means may be used to procure fetuses, such as enslaving healthy women, impregnating them, then aborting the fetus – over and over again. See p. CW77 for a graphic description of this kind of *fetus farming.*

About Our Commentators

"Aquagrrl" is the alias of amateur marine biologist/ecologist Cherry Lake. Aquagrrl denies rumors that she was once a member of the outlawed eco-warrior group Blue Shadow.

Lt. Majid Asad is a biomodified FS-26 Black Widow 2 driver, serving with Navy squadron VF-17 aboard the space cruiser *USS George W. Bush.*

Tatiana Belenko is a Special Agent with the Genetic Regulatory Agency, based in Geneva, Switzerland.

Dr. Tse Chang was Senior Academician of the Transpacific Socialist Alliance's Genetic Planning Council.

Cody Chase is a detective with the Nevada Police Department, where she has dealt with a wide variety of genetic code violations and surgical assault cases.

Marie Detroit is an aspiring pop-singer working as a hostess at the Club Kitsune in Tokyo, Japan.

Genosibyl is the alias of a well-known poster to alt.bio.upgrade.samurai.

Professor C. Eric Gideon of the Antarctic School of Economics is a genome-preservationist and professional gadfly.

Eden Harrier is an expatriate New Zealander, the owner/operator of Harrier Exports. His firm has been investigated for biohazard and customs violations in Asia-Transpacific.

Noriko Hayakawa is an Ishtar-sequence genetic upgrade who hosts the popular talk show, *Cyberia Beat.*

Dr. Sayyid Iqbal is a scientist at Biotech Euphrates' Human Genetic Engineering division. He is a frequent talk show guest.

Copernicus Jones was born in a growth tank on the moon, but is now bumming around the solar system as a travel writer for the best-selling *Lonely System* guidebook series.

Walter Jorgenson was a brilliant young student in molecular biology, until he developed a series of delusions relating to alleged paranormal activity. Arrested in connection with a burglary and arson at a Dogstar Genetics, an Ottawa genetic engineering company, he claimed that the company was a front for "ETs" and "Men in Black." Found not guilty by reason of insanity, he is now confined in an Ontario mental hospital.

Continued on next page . . .

Skills

The following skills are especially relevant to biotechnology:

Genetics/TL — p. B61

This skill has been revised heavily from its original form.

The capabilities and prerequisites of the Genetics skill (p. B61) vary considerably with TL. Its prerequisites are Botany at TL3-4, Zoology *or* Botany at TL5, Physiology at TL6, and Biochemistry at TL7+.

Specialization is *required* (p. B43), in one of two areas:

Genetic Engineering: The manipulation and modification of genes. This specialization is normally only available at TL7+. All gengineers should know this skill.

Heredity: The study of inherited traits and the mapping and sequencing of genomes, as described on p. B61.

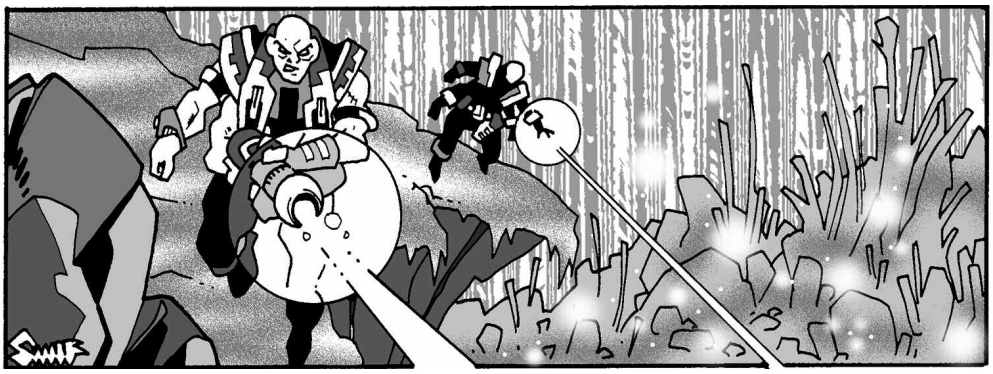
These specializations default to one another at -2.

In both cases, the skill must be *further* specialized to a particular type of biochemistry; e.g., Genetics (Genetic Engineering, Terrestrial). A separate specialization must be learned to engineer organisms from alien biospheres, but a default at -4 or worse may be allowed if the alien biology is quite similar; e.g., terrestrial biochemistry is similar to other biologies that are based on proteins, water and nucleic acids. Within the realm of a particular biochemistry, knowledge of a specific *species'* genetics is a *familiarity* (p. B43), not a specialization.

Nuclear-Biological-Chemical Warfare/TL — p. CI151

Genetic engineers who work with dangerous or contagious microorganisms may have NBC Warfare skill. So will "hazmat" or "disease-control" teams sent to clean up biological disasters.

At TL9+, the "chemical warfare" element of this skill also covers operations in nanomachine-contaminated environments, and techniques used to avoid or clean up nanomachine contamination.



Surgery/TL — p. B56

At TL7+, a surgeon may *optionally* specialize in cosmetic surgery (called "bodysculpting" at TL8+) or transplant surgery. (These can also be performed by unspecialized surgeons.)

Biotech Jobs

Individuals involved in the biotech field may have one of these jobs. See pp. B192-194 for instructions on how to use a job table.

Job Table

Job (Prerequisites) Monthly Income	Success Roll	Critical Failure
Average Jobs:		
Bio-Terrorist (Fanaticism) $1,000	IQ-2	-2i, 2d/-3i, 4d, arrested
Hazmat Specialist (NBC Warfare 11+) $1,000	PR	-1i, 2d/-1i, 4d or infected
Lab Assistant (Computer Operation 10+, Research 11+, any Science skill 10+) $100×(worst PR-6)	Worst PR	-2i/LJ, 2d
Surrogate Mother (HT 11+) HT×$200	HT	LJ/LJ, 3d
Comfortable Jobs:		
Biotech Executive (Administration 13+, 5+ yrs. business experience, Status 0+) $3,000	PR	-2i/-4i, LJ
Eco-Engineer* (Ecology 15+, Genetics 15+) $300×Ecology skill	Worst PR	-2i/-3i, 3d
Ecoteur* (Ecology 15+) $400×Ecology skill	PR	-1i, 2d/-2i, 4d, arrested
Genehacker (Computer Operation 12+, Genetics-14+, Research 13+) $300×Genetics skill	Worst PR	-3i/LJ, 3d
Genetic Regulatory Agent (Criminology 12+, Law 12+, Legal Enforcement Powers) $2,500	Worst PR	-3i, 2d/LJ, 4d
Splicer or Organlegger* (Streetwise 11+, Surgery 10+) $500×Surgery skill	Worst PR	-1i, 2d/3i, 4d, arrested
Wealthy Jobs:		
Biocorp CEO (Administration 13+, Leadership 12+, 10+ yrs. business exp., Status 3+) $175,000	Worst PR	-4i/-5i, LJ
Corporate Genetic Engineer (Genetics-16+, Status 0+) $1,000×PR	PR	-3i/LJ, 3d * Freelance job

Biotech Businesses

Do you want to risk losing that beloved pet? Companion Veterinary Services offers a full range of cloning, longevity processing and braintaping facilities. Specialists in dogs, cats, birds, reptiles, ferrets, octopi. (No robopets, please.)

Various types of businesses may specialize in biotechnology. These can include:

Biotech Corporations

These include companies (or divisions of larger corporations) that specialize in gengineering, protein engineering, biomimetics, genome mapping, genemod drugs, tissue engineering and other processes.

Some biocorps are large enough to cover the entire field, but most specialize in a particular area, such as gengineered crops, industrial bacteria, improved animals, bioroids, terraforming or adapting alien plants and animals. Biotech corporations may also specialize in developing biomodification procedures for use by hospitals and clinics – if a process isn't yet available on the street, someone with contacts in a corporate lab may be able to arrange for it anyway.

Small corporations are often undercapitalized "whiz-kid" operations. These develop a single brilliant idea . . . and are then bought out by a bigger company, usually to market their new invention – but sometimes to suppress it! A certain amount of research may also be contracted out to university labs, in exchange for grants and funding.

About Our Commentators (Continued)

Dr. Lucien Locke is the president and sole employee of Genehackers Inc., an R&D firm specializing in customized biomodification for private clients, and author/star of a number of interactive sensies, including *Playing God for Fun and Profit: Home Study Gengineering* and *Nanovirus for Dummies.*

Tisephone Logos serves the Church of Seventh Heaven (an L-5 colony) as one of their elite "warrior angel" biosoldiers. Although born human, Tisephone has been continuously updated with the latest combat biomods, and is equally at home stalking criminals and genetic heretics in the decadent bubble cities of Luna or the wildzones of post-Nanoclysm Earth. Despite her youthful appearance, she is at least a century old.

Chance Mackintosh speaks her mind in *Posthuman Consumer Review,* a virtuality infodump covering the latest trends in elective surgery from a transgendered perspective. Now in her fourth consecutive clone, she plans to live forever.

Charlie "Big C" Magaddino is an alleged La Cosa crime boss, presently under indictment for numerous state and federal felonies, including tax evasion, conspiracy, surgical assault and kidnapping.

Captain Dana Martello is a former Marine Force Recon medic, presently pursuing a career as a defense analyst. Twice decorated for bravery under fire during the Andes conflict, she is assistant editor of *Jane's Fighting Bioroids.*

Captain Zeke Morrigan is a gengineered spacer parahuman, and master of the free trader *Antares.*

NB-SEK-0172-BUR84 is a Felicia-series combat bioroid. She is assigned to the Indian Army's elite 152nd Paratroop Regiment, with a rank of corporal.

Dr. Mara Omokage is the mysterious and seemingly ageless founder of Omokage Labs, and a specialist in exotic bioweapon design.

Raphael-3000 is a vatbrain computer installed in the Sisters of Mercy hospital on Seventh Heaven.

Continued on next page . . .

About Our Commentators (Continued)

Madeleine Rouge is one of the owners of the Clinic Rouge, "the finest underground clinic in Marseille."

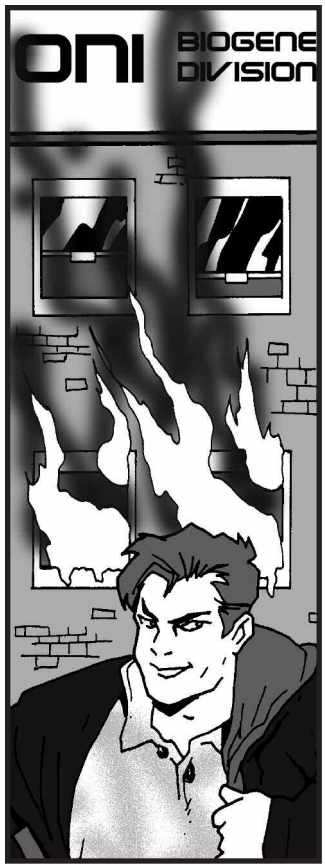
Derin Skay, a writer, was one of the few humans to be unchanged by the Antarctica Nanoclysm.

Streethawk, an outspoken ex-gang member turned self-proclaimed mercenary, is known for his frequent postings on alt.bio.upgrade. samurai.

Tizbeth Sung-Morton is a Camazotz parahuman. She grew up on a seedship in the Darktree Colonization Fleet.

Ensign Chun Yuan was a soldier in the People's Self-Defense Forces of the Transpacific Socialist Alliance, assigned to the Bio-weapons Directorate. His war diary was one of the few primary sources within PSDF-BWD to survive the Pacific War.

Yukio is an Alpha-series genetic upgrade working as an agent for Gomi Crash, a company specializing in macro- and micro-biohazard exterminations, and the tracking, recapture or termination of escaped or outlawed genetic constructs.



If conflict between nations, corporations or star cultures is still an issue, the big research bucks are often in military biotech. "Bioweapon" projects may range from killer viruses to cloned combat bioroids. In a space-faring culture, captured alien life forms may also be studied and modified for military purposes.

Because of the high value and complex nature of many biotech products, industrial espionage is very common. Defense contractors normally have truly paranoid security, since they are worried not just about industrial espionage but also foreign spies and saboteurs. It's possible that corporations which develop military bioweapons may have examples of them deployed to defend their own facilities – or might use them (often without the actual military's knowledge) in corporate espionage or warfare.

Black Clinics

In the future, designer drugs aren't the only things being made in secret labs – so are designer bodies, animal or human, as well as customized life forms. "Black clinic" is the common nickname for a laboratory, clinic or hospital that performs illegal, unregulated or ethically-dubious biomod and gengineering procedures. If cyberwear exists, some may specialize in cybernetics, others in biological procedures, and many in both. Some black clinics are also "body banks," involved in illegal organ theft (see *Organlegger,* p. 129).

Black clinics may range from basement or mobile labs to full-fledged hospitals. The latter are usually disguised as legal body parlors, clinics or biotech companies, but offer extra services to special clients. A black clinic may be able to dispense with secrecy entirely if it can find a location beyond the reach of the law. For example, a black clinic may be based in an orbital habitat, or in a country (or planet) not signatory to international or interstellar regulations on bioengineering ethics.

Security and intelligence agencies may maintain secret black clinics to provide assistance to their agents – often, these also do freelance work on the side.

The biggest danger of going to a black clinic is the risk of shoddy work, closely followed by being made a guinea pig for some experimental process that hasn't been debugged. Finding a disguised black clinic requires appropriate Contacts or Streetwise skill; a critical failure might lead to a police sting operation, or worse, a clinic that looks good but is incompetent, or enjoys experimenting on its subjects or using them for spare parts.

Bodysculpt Clinics and Parlors

These are clinics that specialize in legal bodysculpting jobs (p. 61), although at TL9+, they also carry cheaper proteus viruses, such as metabolic reset (p. 76) and cosmetic virus (p. 78). Some are large, upscale establishments catering to the middle and upper class, often with on-staff psychological counsellors as well as surgeons to ensure smooth integration.

Others are walk-in places that specialize in generic face jobs based on knock-offs of the latest vid star or virtual soap opera character. Those that offer the most radical mods may be descendants of tattoo and body-piercing parlors, catering to subcultures that want to physically distinguish themselves (counter-culture, sailors, yakuza, et cetera). Of course, in some cultures, an "original human" body may be radical, in which case places might specialize in modifying people back to "normal."

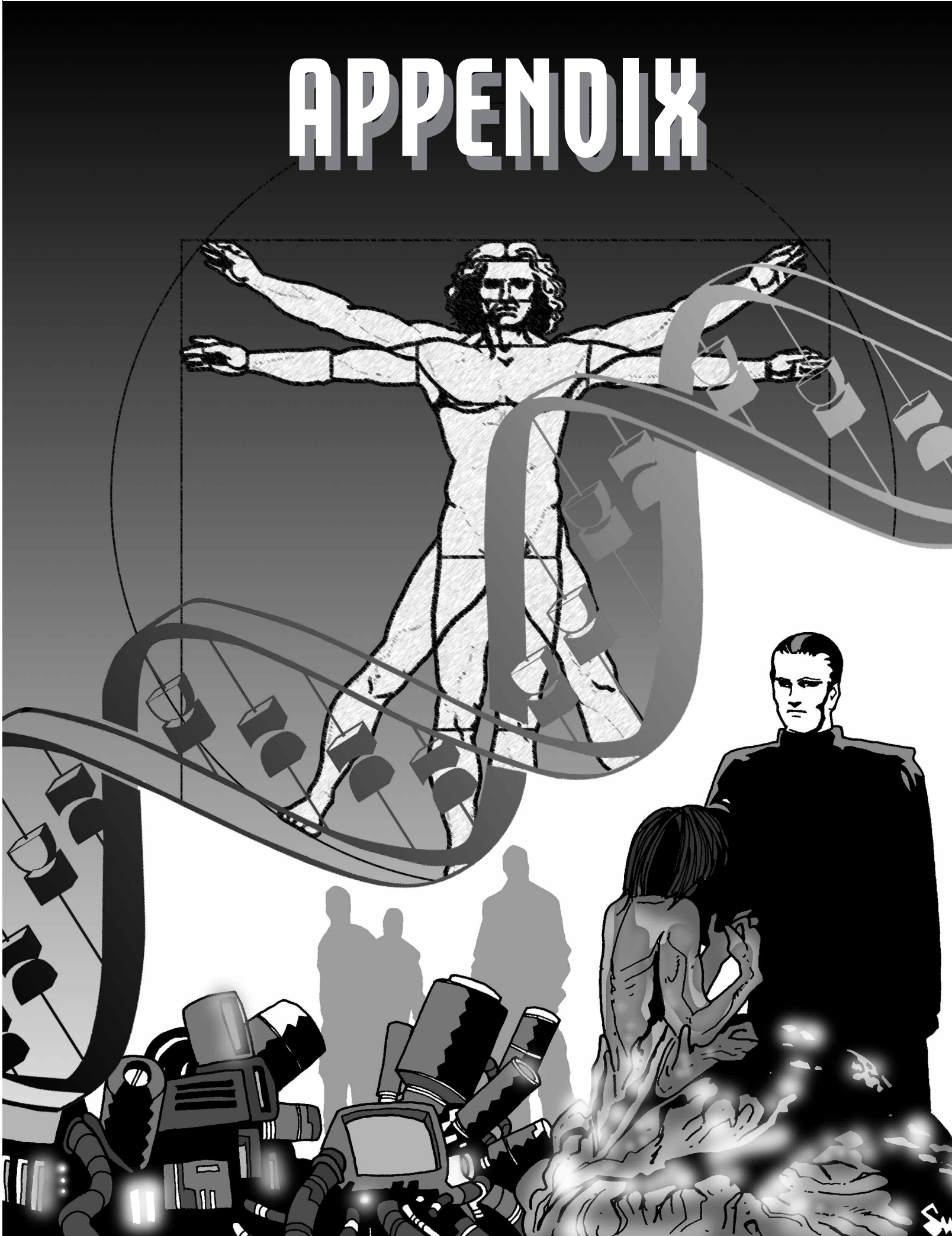
Most clinics will only perform LC 5-6 procedures.

Hospitals

At TL8+, major hospitals may perform elective biomodification procedures, such as transplants, as well as things like braintaping and cloning. Alternatively, specialized private hospitals that provide these services may develop.

Most hospitals will only perform LC 5-6 procedures.

APPENDIX



Biotech Advantages, Enhancements and Limitations

GURPS Bio-Tech uses many advantages, disadvantages, enhancements and limitations that are not described in ***GURPS Basic Set.*** Except for a few new ones described in this chapter, all can be found in ***GURPS Compendium I,*** and many are described in other ***GURPS*** books, notably ***Fantasy Folk, Robots, Supers*** and ***Uplift.***

In addition to the advantages, enhancements and limitations listed here, Chapter 2 has several very minor features worth 0-2 points (e.g., *Sexual and Reproductive Modifications,* p. 47); since these are highly specialized, they're discussed only as they are introduced.

New and Modified Advantages

Extra Arms — p. CI54

Someone with multiple arms should move better and faster than an unimpaired human in microgravity or zero gravity. Add +1 to Move for each full-sized extra arm possessed. See pp. CII140-144 and p. S73 for low-gravity movement rules.

This isn't worth any points – it's a natural benefit of having additional arms in a space environment, and in any case is balanced by the need for custom-tailored suits and armor.

Flesh Pockets — Variable

This is an expanded "racial" version of an advantage that first appeared in ***GURPS Cyberpunk.***

You possess hollow cavities within your living flesh: hidden "flesh holsters," natural pouches such as those possessed by marsupials, or a modified stomach. If the capacity of a flesh pocket is great enough, it can even be used to carry passengers!

Pockets and their contents are almost impossible to find (Holdout-20), even with a full-body search, but they can be spotted with appropriate scanners. A doctor specifically searching for flesh pockets rolls at Physician-6 or Surgery-6, with a +1 per extra 10 minutes of searching, to a maximum of +5.

Flesh pockets are usually in the stomach. The *total* capacity of all flesh pockets in a person's stomach should not exceed 20 lbs. For races whose average weight is below 100 lbs. or above 200 lbs., the maximum capacity should be racial average weight/10 lbs. This limit is modified as follows: -50% if Skinny, +50% if Overweight, +75% if Fat or +100% if Very Fat.

Pockets in the stomach cost 2 points per pound if the user is human-sized. For races with average weight over 200 lbs. the point cost paid for each flesh pocket is 2 points per (racial average weight/200) storage capacity.

EXAMPLE: A bioship that weighs 25,000,000 lbs. could have pockets with a total capacity of up to 2,500,000 lbs. and would pay 2 points for every 125,000 lbs. of pocket capacity.

Pockets may be installed in places other than the stomach, but these are more expensive and have less capacity. Pockets in a limb have only 15% of the maximum capacity and cost 2.5 times as much. Pockets in a head have a maximum capacity 1/80 as great (4 oz. in humans) and cost 8 times as much (1 point per oz. in a human) but are harder to detect: +2 to Holdout.

Pockets are only an advantage for living creatures, where they are unexpected; machines built using the ***GURPS Robots*** or ***Vehicles*** system don't pay points for cargo holds.

Fur — p. CI56

Soldiers operating in the arctic report that animals with thick fur are hard to spot on infrared. Optionally, in sub-zero temperatures, the GM may subtract the level of Temperature Tolerance that fur provides from rolls to spot fur-bearing targets via Infravision or infrared goggles: -2 if thick fur, -1 if normal fur, 0 if very thin fur. This doesn't cost any extra points.

Someone with *spiny fur* can't wear tight clothing or armor.

Low Rejection Threshold — 1 point

Your body can easily accept foreign tissue transplants, with no roll for rejection required. This advantage is worth points only in TL7+ settings, and only if cloned or synthetic organs are unavailable or are significantly more expensive than other types.

Someone with Low Rejection Threshold may have HT no higher than 12 and may not buy Disease Resistant or Immunity to Disease.

New Enhancement

Several enhancements can be found on p. CI109.

Space Acceleration — Variable

This enhancement can only be taken for the Flight advantage. You can use your Flight to accelerate in space like a rocket, and have a space acceleration (sAccel) rated in gravities (G), as described in ***GURPS Space*** or ***Vehicles.*** This means that in space, you can accelerate past your normal Move, given enough time. For +5%, your sAccel is 0.001 G, limiting you to very gradual velocity changes. For +10%, it is 0.01 G, for +15%, it is 0.1 G, for +20%, it is 0.5 G and for +25%, it is 1 G.

Each level of Super Flight *doubles* your space acceleration.

New Limitations

These new limitations are often applied to advantages or disadvantages that are the result of biological engineering. More limitations can be found on p. CI110-112.

Cardiac Stress — Variable

This limitation can be taken on any advantage that is used for a short period of time and then turned off. While in use, the advantage places undue stress on the character's heart, and the character must make periodic HT rolls (a roll of 14+ always fails). Failure means loss of 1d fatigue; critical failure means a heart attack due to stress and heightened blood pressure. A heart attack reduces the victim to HT 0 if still at positive HT. He passes out and will die in HT/3 minutes – regardless of wounds – unless he receives CPR (which requires a First Aid-4 or Physician roll, and can only be performed by a character trained at TL7+).

The value of this limitation depends on how often the HT rolls are made:

Every second: -50%
Every 10 seconds: -40%
Every minute: -30%
Every 10 minutes: -20%
Every hour: -10%

Chemical Trigger — Variable

This limitation means that an advantage only functions after the character has taken a particular drug. In general, this means the character must inject, swallow or inhale a drug to trigger the advantage. For instance, Matsai Accelerated Reflexes need an inhaled dose of the Dash IV hormone to trigger them. The cost of the trigger determines the value of the limitation:

Under $10 per dose: -10%
$10-99 per dose: -20%
$100-999 per dose: -30%
$1,000+ per dose: -40%

Multiply the value of the limitation by 1.5 if the chemical trigger is illegal, addictive or otherwise dangerous.

Mitigator — Variable

A mitigator is something that cancels the effect of a specific disadvantage without actually buying it off. This is a limitation *on the disadvantage:* The more effective the mitigator, the greater the limitation, meaning the character receives fewer points for the disadvantage.

The mitigator is worth . . .

-60% if *vulnerable* and can be easily stolen, broken or misplaced, such as a pair of glasses. This mitigator also includes drugs or other treatments that must be taken *daily.*

-65% if a *weekly* treatment is required.

-70% if a *monthly* treatment is required.

Drug treatments are assumed to cost about $20-$100 per dose and be available at pharmacies. Those that cost over $100/dose and require special prescriptions are +5% less (e.g., -70% would become -65%). Those costing $1,000+ per dose and only available from specialized sources like hospitals or experimental drug programs are +10%. People may carry a supply of drugs with them, but these can be stolen, lost or turn out to be impure.

EXAMPLE 1: Mr. Duncan has Sadism (Mitigator, -60%, -6 points). As long as he takes a special pill ($20, daily) to adjust his neurochemistry, he is an upstanding citizen . . but if someone steals his pills, an enemy substitutes aspirin for them, or he forgets them on a long trip, society is in deep trouble.

EXAMPLE 2: Sharra has eyeglasses. Bad Sight is normally -25 points, but her glasses are a -60% limitation: -10 points. This is a mitigator built into the ***GURPS Basic Set.*** The same rules can be used for things like hearing aids.

EXAMPLE 3: Jan is Terminally Ill with AIDS, and will die in a month (-100 points). Fortunately, he is on an experimental drug plan that is holding him in remission. The treatments are weekly (-65%) and cost $1,000 per week (+10%) for -55%, so Jan's Terminally Ill is now worth -45 points. As long as he stays with the program, the countdown toward his death will be halted.

Nuisance Effect: Temporary Disadvantage — Variable

This limitation can be added to any advantage that can be switched "off" and "on" at will, and which takes at least one turn to switch. When the advantage is switched on, one or more disadvantages are suffered by the user until it is switched off again. This limitation is worth -1% per point the temporary disadvantages are worth, to a maximum of -75%.

EXAMPLE: A character has sonar, but can't talk when he's using it because he's sending out ultrasonic pulses. This is Sonar Vision (25 points) with Nuisance Effect: Mute (-25%), for 19 points.

The *point break* due to a Nuisance Effect: Temporary Disadvantage limitation cannot exceed 80% of the value of the original disadvantage.

EXAMPLE: A character has Altered Time Rate 1 (100 points) with Nuisance Effect: Bad Temper (-10%). Since Bad Temper is worth -10 points normally, the most it can be worth as a Nuisance Effect is -8 points. Thus, it reduces the cost of Altered Time Rate by 8 points (to 92 points) and not by 10 points (to 90 points), as most -10% limitations would.

Only disadvantages that could logically inconvenience the character for the period of time the advantage is normally on should be permitted. In the case of mental disadvantages (e.g., Berserk, Bloodlust, Lecherousness, et cetera), if the character loses control of himself due to a failed Will roll, the associated disadvantage will not "turn off" until the GM rules he has regained his composure.

If the GM agrees, a Nuisance Effect can also temporarily remove some other advantage instead of bestowing a disadvantage. This would be worth -1% per point the negated advantage is worth. The value cannot exceed 80% of the deactivated advantage's cost. Only one of the involved advantages can take this limitation – one may *not* take two advantages, both with this limitation, each of which negates the other when used.

Off-the-Shelf Looks -50%

This is a limitation on Appearance; it can be taken on either Beautiful/Handsome or Very Beautiful/Handsome. Your looks are a variation on a standard type or famous person rather than a customized design. You're as beautiful as ever, but with anyone from your own culture, you get only half the usual reaction bonus, because they've seen it all before! ("Oh, look! *Another* Mr. Universe 2023!")

Only vs. Pheromones -75%

This limitation is usually taken with Weak Will, representing someone gengineered to have a strong reaction to human pheromones; see *Restored Vomeronasal Organ* (p. 37).

A variant of this is "Triggered By Pheromones" (-75%), which can be taken as a limitation on other behavioral disadvantages. For example, someone exposed to Pheromone Control or another source of tailored pheromones would suffer another disadvantage (e.g., Cowardice) in addition to the normal effects (usu. Lecherousness).

Only With Duplicate -70%

This limitation can be taken on advantages or disadvantages that apply only toward a braintaped double (or, less realistically, with an identical twin or clone). For example, someone may have Empathy, Only With Duplicate for 5 points. In some cases, this limitation may be worth less – see *Multiple People* (p. 118) for details.

Post-Emergencies Only -50%

This limitation means that an advantage or, more often, a disadvantage, only comes into play *after* a stressful event like combat has occurred. The effects will last for about 10 minutes or so (GM's option). Typically, this limitation is applied to a behavioral disadvantage – e.g., "Gluttony (Post-Emergencies Only)" – to simulate glandular reactions following stress.

Requires Biochip -5%

A tiny biocomputer chip must be implanted into the body to make the advantage or disadvantage function. This is a limitation because the chip can sometimes be detected (requires a Diagnosis roll at -10, using a medscanner, diagnosis bed or the like) and removed (a normal use of Surgery skill) relatively easily, neutralizing the advantage or disadvantage. The biochip may also malfunction if subjected to radiation or the like.

A biochip might be remotely controlled by someone *other* than the subject! If they do not always have the subject's best interests at heart, this would be an +5% *enhancement* to the value of a disadvantage, not a limitation.

Requires Low Gravity Variable

This limitation means that an advantage does not function in gravity fields over a certain, maximum strength. It is worth -5% for every 0.1 G this maximum is under 1 G, as follows: maximum 0.9 G is -5%, 0.8 G is -10%, 0.7 G is -15%, 0.6 G is -20%, 0.5 G is -25%, 0.4 G is -30%, 0.3 G is -35%, 0.2 G is -40%, 0.1 G is -45% and 0 G is -50%.

Requires Low Gravity should be applied to humans gengineered with Clinging (usually maximum 0.6 G), Gliding (usually maximum 0.4 G) or Winged Flight (usually maximum 0.2 G). It can also be an appropriate limitation for some super or psi powers – like Body of Air, DR, Insubstantiality, Telekinesis or Teleportation – if a gravity field might disrupt fragile force fields.

Scent-Based -20%

This limitation represents an advantage (usually one that allows a reaction bonus or "mind control") that operates using specialized airborne chemical cues – perhaps modified pheromones. It only works within 2 yards of someone, and only if they have a sense of smell and neither they nor you are using gas masks, sealed suits, et cetera.

Sessile -75%

Characters with the Sessile disadvantage (p. CI104) may buy Extra Hit Points with this similarly-named -75% limitation to partially compensate for the fact that they are easier targets.

Unsupported Strength -25%

This limitation can be taken on some or all of any ST increase of +3 or more that's due to biomods or gengineering. It represents a shoddy job of muscle attachment, or not bothering to take the time to build up bone mass first. This will result in a split ST, with the second, higher ("unsupported") ST being bought with this -25% limitation. Normal ST is used for encumbrance, fatigue and most other purposes. However, for any *transitory* feat of strength – including lifting, jumping, grappling, throwing or attacking – you can choose to use your unsupported ST. No roll is required to use the strength, but in the following turn, roll vs. HT. Success means no problem occurs, but a failure causes 1 point of damage; critical failure, or two failures on consecutive turns, does 1d damage and causes any one limb you are using to be *crippled.*

GLOSSARY

This section defines both scientific and fanciful terms found in this book and in biotechnology literature.

Technical Terms

Amino Acid: An organic compound that is an essential component of *protein* molecules, and thus of life as we know it.

Archaea or **Archaebacteria:** An ancient form of microbial life, related to but distinct from *bacteria.*

Bacteria (sing. "bacterium"): A class of single-celled organisms. There are countless species of bacteria.

Biomimetics: Engineering designs that are patterned on or inspired by living things.

Bioprocessing: Using *bacteria,* gengineered plants and animals or other *biotech* processes in manufacturing.

Biotech or **Biotechnology:** A set of biological engineering techniques, such as *biomimetics,* bio-nanotech, *bioprocessing, cloning, gengineering,* and transplants, applied to research and product development.

Blastocyst: A very early stage of a developing embryo, with only 32-64 *cells.*

Cell: The smallest part of an organism that is capable of independent function. Cells are microscopic entities that consist of a nucleus and various organic and inorganic components, surrounded by a membrane.

Chromosomes: The self-replicating structures within *cells* on which the *genes* are located.

Cloning: The technique of asexually producing a group of *cells* or complete organisms, called clones, which are all genetically identical to a single ancestor.

Cryonics: The practice of freezing the dead in hope that future science will be able to revive them.

DNA or **Deoxyribonucleic Acid:** The double-helix-shaped molecule that encodes genetic information.

Enzyme: A *protein* that serves as a chemical catalyst, accelerating the rate at which a biochemical reaction occurs.

Eugenics: The study or practice of human improvement through genetic control or *genetic engineering.*

Eukaryotes ("true nucleus"): Organisms whose *DNA* is surrounded by a membrane and which possesses *organelles*. Eukaryotes are a "superkingdom" of life forms that include most terrestrial plants and animals other than *bacteria.*

Gamete: A male or female reproductive cell (sperm or ovum).

Gene: A sequence of *DNA nucleotides,* located in a particular spot on a particular *chromosome,* that encodes a specific instruction to a *cell.*

Gene-Cloning: The process of duplicating *genes* inside modified *bacteria.*

Gene Therapy: *Genetic engineering* performed on a fetus, child or adult to repair defective *genes.*

Genetic Engineering or **Gengineering:** Deliberate manipulation of *DNA* and *genes* in order to alter an organism's *genome.*

Genetics: The study of the patterns of heredity, the traits that an organism inherits from its ancestors.

Genome: The sum total of all the genetic material carried by the *chromosomes* of a particular organism, containing the blueprint of what the organism will become.

Germ Cells: The basic reproductive cells of a multicellular organism; see *gametes.*

Germline Gengineering: *Genetic engineering* of the *germ cells* so that an organism will develop in a different way than its unmodified *genome* would have indicated.

Hormone: A *protein* that acts as a chemical messenger within the body. They are many different hormones, each with its own function.

In vitro: Taking place outside a living organism, usually used when referring to "test tube" fertilization or to the process of growing an organism in an artificial womb, clone tank, et cetera.

Intron: "Junk" *DNA* code that has no apparent purpose.

Ligase: An enzyme that can rejoin *DNA* fragments together, used as a tool in *genetic engineering.*

Microbiological: A single-celled organism, like a *bacterium* or alga. Usually microscopic, but colonies of single-celled organisms can be large enough to see.

Nanomachine: A microscopic organic or inorganic robot, usually cell-sized or smaller.

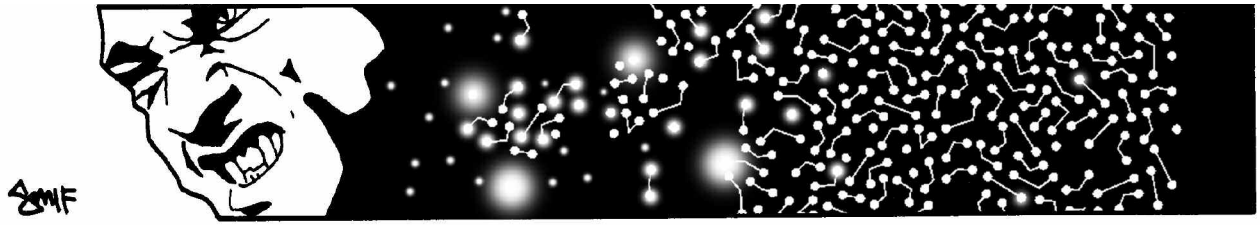
Nanotech or **Nanotechnology:** An emerging technology based around the manipulation of atoms and molecules using microscopic machines. In *biotechnology,* nanotech promises the ability to precisely manipulate *cells* and *genes.*

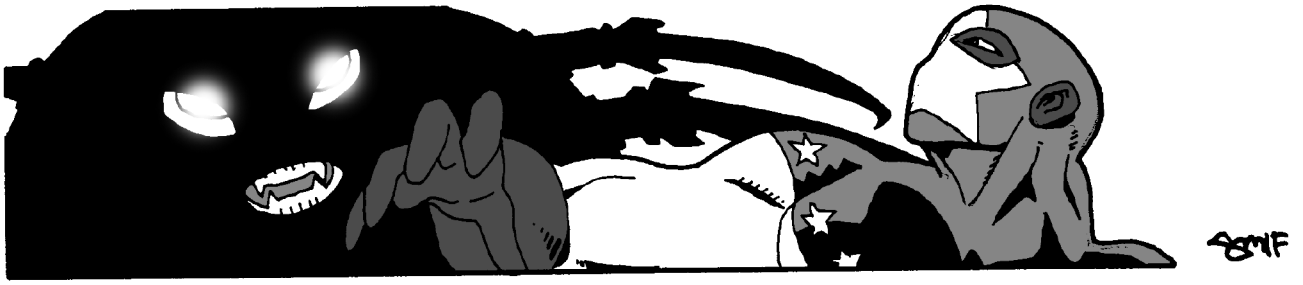
Nucleotides: The basic molecular subunits of *DNA* or *RNA.* Thousands of nucleotides make up DNA molecules; their sequence determines the genetic code and the function of each *gene.*

Organelles: Structures bound by the *cell* membrane in *eukaryotic* organisms, such as the mitochondria (which perform energy-releasing chemical reactions).

Plasmid: A ring-shaped structure of *DNA,* found in *bacteria.*

Polymerase Chain Reaction (PCR): A means of rapidly copying *DNA* using specialized *enzymes* and equipment.





Prions: Pathogenic *proteins* linked to various brain diseases such as BSE ("mad cow disease") and kuru ("laughing sickness"). Prions are also associated with various diseases of aging and senility. Their exact nature remains controversial.

Prokaryotes ("before the nucleus"): Single-celled organisms with little internal complexity, such as *bacteria,* whose *DNA* is not surrounded by a membrane and which lack *organelles.*

Protein: A big molecule made up of long chains of *amino acids.* Proteins are formed by *cells* as directed by their *genes,* and are the basis for the structure and function of living things. There are countless different kinds of proteins, each with its own specialized function.

Protozoan: A single-celled microscopic animal somewhat more complex than a *bacterium.*

Recombinant DNA: The basis of *genetic engineering,* this is the technology of cutting *DNA* molecules into discrete pieces and recombining them with other DNA molecules to form new *genes.*

RNA or **Ribonucleic acid:** A chemical found inside *cells* that is similar in structure to *DNA.* Different kinds of RNA exist, such as messenger RNA, which relays the orders from *genes* to the molecular machinery of cells. Because of its ability to tell a cell what to do, RNA is a primary tool of gengineers.

Ribosome: Parts of the *cell*'s molecular machinery, these are "factories" that create *proteins* under orders from the *genes.*

Tissue Engineering: The design of artificial organic tissue.

Transgenic: A transgenic organism is one that has *genes* added to it from outside its original species.

Virus: A non-cellular biological organism that can reproduce only within a host *cell.* Viruses consist of *RNA* or *DNA* covered by *protein.* RNA viruses are especially useful tools for *gengineering.*

Science-Fiction Terms

Android: A completely synthetic humanoid. An android may be biological or robotic in nature. Some androids have non-human features, while others look exactly like people.

Biomod: A biological modification made to a living person for non-medical purposes. At TL7, the only biomods are cosmetic surgery. At TL8+, biomods become the organic equivalent of cybernetics, giving people many new abilities.

Bio-Nanotech: Nanotechnology that relates to biotechnology — for example, a *nanovirus.*

Bioplastic: A pseudo-organic TL10 material. Not to be confused with certain kinds of plastic made from organic materials like starch, which are also called bioplastics.

Bioroid ("biological android"): A *variant human* (or humanoid) who was *force-grown* to maturity in a *clone tank.*

Braintaping: A means of recording memory and personality, for immediate or later transfer to another body.

Clone Tank: An ultra-tech artificial womb equipped to *force-grow* organisms (not necessarily clones) to adulthood.

Corpsicle: A corpse that has undergone cryonic preservation. A term coined by SF author Larry Niven.

Eugeneering: Genetic engineering for eugenic purposes.

Forced-Growth: A way of hyper-accelerating the development of someone within an artificial womb so that maturation from a germ cell to a developed adult takes months, not decades. It may use massive doses of growth hormones or other methods.

Genefixed: Used to describe someone whose genes were manipulated at conception to fix or screen out genetic defects.

Genemod: Short for "genetically modified." Someone or something that has undergone genetic engineering. Also refers to a genetic modification.

Genesplice: To perform genetic manipulation.

Ghostcomp: A computer capable of housing a self-aware *braintape.*

Growth Tank: An artificial womb.

Korp or **Korporate:** Cyberpunk slang for "corporate."

Metamorphosis (Nano)Virus: A *nanovirus* capable of performing radical changes in a living being's anatomy.

Nanite, Nano and **Nanobot:** Slang terms for nanomachines.

Nanovirus: A swarm of nanomachines designed to transform a living organism or perform gengineering tasks.

Parahuman: A *variant human* who has undergone *species modification.*

Polykeratin: A form of artificial tissue that is capable of changing its shape.

Proteus Virus: Another name for a *nanovirus.*

Sensa-Skin: An ultra-tech form of artificial tissue.

Species Modification: Genetic modification that inserts new genes not native to a species' original genome.

Uplift: The process of modifying animals to improve their intelligence, communications or tool-using capabilities, often with the goal of creating a sentient or near-sentient race. A term coined by SF author David Brin.

Uploading: Slang term for transferring a mind onto a digital *braintape,* especially when the braintape is self-aware in a *ghostcomp.*

Variant Human: A member of a human *variant race.*

Variant Race: A subspecies that has been adapted from the original species through genetic engineering. Depending on the extent of the gengineering, it may be similar to or very different from the original.

BIBLIOGRAPHY

There are far too many works of fact and fiction to cover in this brief space – instead, this bibliography concentrates on books especially useful in inspiring adventures and game settings. The categories given below are to make research easier – most books will overlap into several topics.

Fiction

Altered People and Posthuman Societies

Banks, Iain M. *Culture* series, especially *Excession* (Bantam-Doubleday-Dell, 1996).
Bear, Greg. *Queen of Angels* (Warner, 1990).
———. *Slant* (Tor, 1997).
Blish, James. *The Seedling Stars* (New American Library, 1957).
Brin, David. *Otherness* (Spectra, 1984).
Di Filippi, Paul. *Ribofunk* (Four Walls Eight Windows, 1996).
Dixon, Dougal. *Man after Man* (St. Martins, 1990).
Evanier, Mark. *DNAgents* comics (Eclipse).
Egan, Greg. *Quarantine* (Harper, 1992).
Hansen, Karl. *War Games* (Berkley, 1983).
Heinlein, Robert. *Friday* (Ballantine, 1982).
Herbert, Frank. *Hellstrom's Hive* (Bantam, 1973).
Kress, Nancy. *Beggars in Spain* (Avon, 1993).
———. *Beggars and Choosers* (Avon, 1994).
O'Donohoe, Nick. *Too, Too Solid Flesh* (TSR, 1989).
Shirow, Masamune. *Appleseed* graphic novels (Dark Horse).
Sterling, Bruce. *Holy Fire* (Bantam-Doubleday-Dell, 1996).
———. *Schismatrix Plus* (Ace, 1996).
Stirling, S.M. *Drakon* (Baen, 1996).
Varley, John. *The Persistence of Vision* (Ace, 1978).
———. *Steel Beach* (Ace, 1992).
Warren, Adam. *Dirty Pair* graphic novels (Dark Horse).

Bioengineered Plants or Animals

Crichton, Michael. *Jurassic Park* (Ballantine, 1990).
Martin, George R. R. *Tuf Voyaging* (Simon & Schuster, 1986).
Easton, Thomas A. *Sparrowhawk* (Ace, 1990).

Biological Weapons and Disasters

Bear, Greg. *Blood Music* (Ace, 1985).
Shirley, John. *Eclipse: Corona* (Popular Library, 1990).
Clancy, Tom. *Executive Orders* (Berkley, 1996).
Herbert, Frank. *The White Plague* (Putnam, 1982).
Kress, Nancy. *Oaths and Miracles* (Avon, 1997).

Cryonics

Bear, Greg. *Heads* (Tor, 1990).
Niven, Larry. *A World Out of Time* (Ballantine, 1976).

Braintaping, Body Transfer and Uploading

Egan, Greg. *Permutation City* (Harpers, 1995).
Farmer, Philip Jose. *To Your Scattered Bodies Go* (Berkley, 1971).
Lee, Tanith. *Don't Bite the Sun* (DAW, 1976).
Varley, John. *The Ophiuchi Hotline* (Ace, 1984).
Williams, Walter Jon. *Voice of the Whirlwind* (Tor, 1987).
Zelazny, Roger. *Lord of Light* (Avon, 1967).

Human Cloning

Cherryh, C.J. *Cyteen* (Warner, 1988).
———. *Serpent's Reach* (DAW, 1980).
Levin, Ira. *The Boys from Brazil* (Bantam, 1976).
Weaver, Michael D. *Mercedes Nights* (St. Martins, 1987).

Nonhuman Biotechnologies

Butler, Octavia. *Xenogenesis* (Warner, 1987).
Harrison, Harry. *West of Eden* (Bantam, 1984).
Niven, Larry. *World of Ptaavs* (Ballantine, 1966).
Norton, Andre. *Judgement on Janus* (Ballantine, 1963).
Williams, Walter Jon. *Angel Station* (Tor, 1989).

Organ Transplants

Niven, Larry. *The Long ARM of Gil Hamilton* (Ballantine, 1976).
———. *A Gift From Earth* (Ballantine, 1968).

Uplifted Animals

Brin, David. *Startide Rising* (Spectra, 1983).
———. *The Uplift War* (Bantam, 1987)
Crowley, John. *Beasts* (Bantam, 1976).
Gallacci, Steve. *Albedo* series (Antarctic).
Smith, Cordwainer. *Norstrilia* (Nesfa, 1975).
Smith, L. Neil. *The Probability Broach* (Tor, 1980).
Swann, S. Andrew. *Forests of the Night* (DAW, 1993).
Wells, H.G. *The Island of Dr. Moreau* (Everyman Library, 1993).
Zelazny, Roger. *The Dream Master* (Ace, 1966).

Popular Science

Benyas, Janine M. *Biomimicry: Innovation Inspired by Nature* (William Morrow, 1997).
Conick and Wheelis. *The Cartoon Guide to Genetics* (Harper, 1991).
DeSalle and Lindley. *The Science of Jurassic Park* (Basic Books, 1997).
Drlica, Karl. *Understanding DNA and Gene Cloning* (Wiley, 1992).
Downer, John. *Supersenses: Perception in the Animal World* (BBC Books, 1988).
Drexler, E., Peterson, C. and Pergamit, G. *Unbounding the Future: the Nanotechnology Revolution* (Quill, 1993).
Grace, Eric. *Biotechnology Unzipped* (Trifolium, 1997).
Lee, Thomas F. *Gene Future* (Plenum, 1993).
McKim, William A. *Drugs and Behavior* (Prentice-Hall, 1986).
Pinel, John. *Biopsychology* (Simon & Schuster, 1990).
Regis, Ed. *Great Mambo Chicken and the Transhuman Condition* (1990).
Steen, R. Grant. *DNA and Destiny* (Plenum, 1996).
Watson, James. *The Double Helix* (Penguin, 1969).

Many magazines and web pages have articles on biotech and related technologies.

Games

Chadwick, Miller, Brown and Smith. ***2300*** (GDW, 1992).
Farshtey, Gordon, Stark and Bambra. ***Space Gods*** (West End, 1991).
Jones, Stefan. ***GURPS Uplift*** (Steve Jackson Games, 1990).
Kidd, Paul. ***Albedo*** (Chessex, 1988).
Laker, Laker, and Pevs. ***Skyrealms of Jorune*** (Chessex, 1985).
Sheeley, Craig. "Exotics," ***Chromebook 2*** (R. Talsorian Games, 1992).
Pulver, David. "The Medusa Sanction," ***GURPS Cyberpunk Adventures*** (Steve Jackson Games, 1992).
———. ***Ultra-Tech II*** (Steve Jackson Games, 1997).
Winters and McLaughlin. ***Technocracy: Progenitors*** (White Wolf, 1993).
Wu, Karl. ***Shadowtech*** (FASA, 1992).

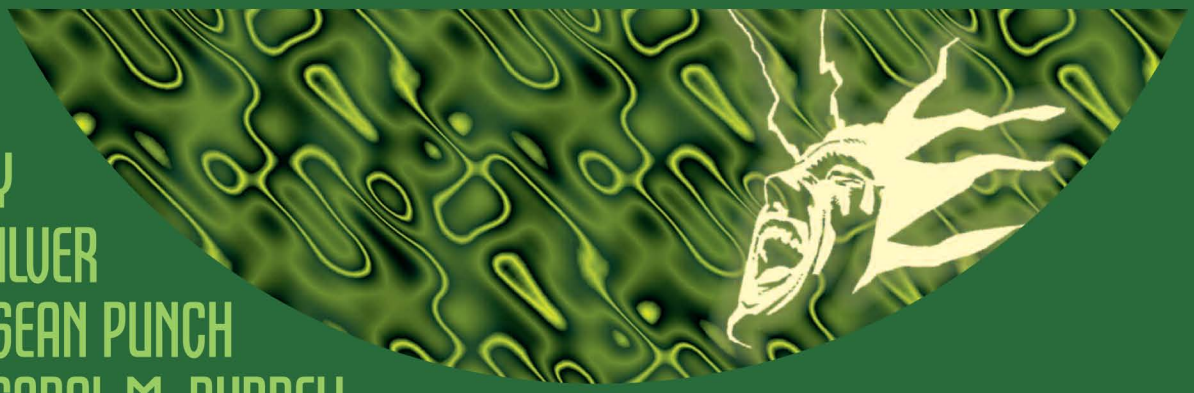
INDEX

THE FUTURE IS ALIVE

"Who needs chrome, pal? Raw meat is where it's at now. Mother Nature always did it best – she just needed a little help. Get down to the black clinic, old-timer, and you can be 15 again. That is, if you still want to be human at all . . ."

Who needs silicon and steel? Upgrade your old body with steroids and smart drugs, transplants and viral nano . . . or just get a new one. Or maybe you don't think being human is so great? Then improve on nature with eugeneering and genefixing, or just go *para*human: Why just admire cats when you can *be* one? The technology's changing fast, but you'll have lots of time to get used to it – death is a temporary nuisance with cryonics, cloning and braintaping.

Welcome to the post-human age. Have you upgraded your genetics this year?



WRITTEN BY
DAVID L. PULVER
EDITED BY SEAN PUNCH
COVER BY CAROL M. BURRELL
ILLUSTRATED BY DAN SMITH

First Edition – Published January 1998

Both ***GURPS Basic Set,*** *Third Edition Revised* and ***Compendium I: Character Creation*** are *required* to use this supplement in a ***GURPS*** campaign. However, the detailed, factual discussions of cutting-edge biotechnology will support high-tech adventures with *any* game system!

STEVE JACKSON GAMES®

ISBN 1-55634-336-1
52095
9 781556 343360
SJG02095 **6524**
Printed in the U.S.A.